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EVALUATION OF AN OH-58A HELICOPTER WITH AN ALLISON 250-C20B ENGINE

FINAL REPORT

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UNITED STATES ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
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The United States Army Aviation Engineering Flight Activity conducted a limited performance and handling qualities evaluation of a Bell Helicopter Company OH-58A helicopter with an Allison 250-C20B engine installed. The evaluation was conducted at Edwards Air Force Base and Bishop, California, from 17 October through 6 December 1974. Twenty-two flights with 17.6 productive test hours were required for the evaluation. Test results obtained with the Allison 250-C20B

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20. Abstract

engine were compared with those previously obtained with the Allison 250-C20 engine and the standard T63-A-700 engine. Primary performance improvement over the standard T63-A-700 engine was an increase in out-of-ground-effect hover ceiling from 4600 to 11,050 feet standard-day density altitude at a gross weight of 3000 pounds. One deficiency and five shortcomings were noted. The deficiency was the considerable pilot compensation required to maintain aircraft control in left lateral accelerating flight. The shortcomings consisted of (1) insufficient left pedal in right sideward flight, (2) insufficient aft cyclic control in rearward flight, (3) extensive pilot compensation required in left sideward flight, (4) moderate pilot compensation required to maintain right accelerating flight, and (5) the unsatisfactory governing characteristics of the OH-58A helicopter equipped with an Allison 250-C20B engine. These unsatisfactory handling qualities characteristics are inherent to the basic OH-58A helicopter and are not associated with the installation of the 250-C20B engine. The engine/airframe compatibility characteristics (cooling and vibration levels) of the OH-58A helicopter with the 250-C20B engine are similar to the standard OH-58A helicopter with the T63-A-700 engine. Within the scope of the test, the performance of the OH-58A helicopter with an Allison 250-C20B engine installed was improved over the basic OH-58A helicopter. Handling qualities were essentially unchanged.

PREFACE

Throughout this evaluation, technical support was provided by the engine manufacturer, Detroit Diesel Allison Division of General Motors Corporation, Indianapolis, Indiana. Emergency fire fighting and medical support were provided by the United States Air Force Flight Test Center, Edwards Air Force Base, California.

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INTRODUCTION

BACKGROUND

1. Engineering flight tests were previously conducted by the United States Army Aviation Systems Test Activity (USAASTA) (since redesignated the United States Army Aviation Engineering Flight Activity (USAAEFA)) to determine the performance and handling qualities characteristics of a Bell Helicopter Company (BHC) OH-58A helicopter equipped with Allison T63-A-700 (refs 1 and 2, app A) and 250-C20 (ref 3) gas turbine engines manufactured by the Detroit Diesel Allison Division of General Motors Corporation. It was subsequently determined that an evaluation of the performance, handling qualities, engine/airframe interface, and engine cooling characteristics of an OH-58A helicopter with an Allison 250-C20B engine installed was necessary. In June 1974, the United States Army Aviation Systems Command (AVSCOM) directed USAAEFA to conduct that evaluation (ref 4).

TEST OBJECTIVES

2. The objectives of this evaluation were to determine the aircraft performance and handling qualities, and engine vibration and temperature characteristics of an OH-58A helicopter with an Allison 250-C20B engine installed. Specific objectives were as follows:

a. Evaluate compatibility of the engine/airframe, to include engine vibration characteristics.

b. Determine the engine nacelle and lubrication system cooling characteristics.

c. Determine the performance characteristics and handling qualities at low and high-altitude test sites.

DESCRIPTION

3. The Allison 250-C20B engine is a growth version of the 250-C20 engine incorporating a redesigned combustor and turbine. For this evaluation, the test engine was equipped with a Bendix fuel control system and was restricted to the helicopter's transmission takeoff power limit of 317 shaft horsepower (shp) from its uninstalled static sea-level takeoff power rating of 420 shp. A detailed description of the Allison 250-C20B engine is contained in the installation design manual (ref 5, app A). A general description of the engine is contained in appendix B.

4. The test aircraft, a JOH-58A light observation helicopter, serial number 68-16706, was manufactured by BHC, Fort Worth, Texas. The single main rotor is a two-bladed, semirigid, teetering type and the tail rotor is also of the two-bladed, semirigid, teetering type with delta-hinge coupling. The cockpit provides side by side seating for a crew of two (pilot and copilot/observer) and the cargo compartment has seats for two passengers. The cyclic and collective controls are hydraulically boosted and irreversible, while the directional controls on the standard configuration are unboosted and reversible. The modifications incorporated in the test helicopter which resulted in the "J" designation were installation of a BHC electronic 3-axis stability and control augmentation system (SCAS) which incorporates a hydraulically boosted and irreversible directional control and a Sperry helicopter command information system (HCIS). A detailed description of both systems is contained in USAASTA Final Report No. 72-20 (ref 6, app A). The landing gear consists of fixed skids. The helicopter is normally powered by an Allison T63-A-700 (Allison 250-C18) free gas turbine engine with an uninstalled takeoff power rating of 317 shp at static sea-level, standard-day conditions. The main transmission has a rating of 270 shp for continuous operation, with a takeoff power limit of 317 shp (5-minute rating). A detailed description of the standard OH-58A helicopter is contained in the operator's manual (ref 7).

TEST SCOPE

5. The performance, handling qualities, and engine/airframe interface evaluations of the Allison 250-C20B engine installed in a JOH-58A helicopter were conducted by USAAEFA personnel. Testing was performed at Edwards Air Force Base (elevation 2302 feet), Bishop (elevation 4120 feet) and Coyote Flats (elevation 9980 feet), California, from 17 October through 6 December 1974. Twenty-two test flights for a total of 17.6 productive hours were flown. Flight limitations contained in the operator's manual and the safety-of-flight release (ref 8, app A) were observed during the testing. Test conditions are shown in table 1. The test aircraft was evaluated against the requirements of military specifications MIL-H-8501A (ref 9) and MIL-T-25920 (USAF) (ref 10).

TEST METHODOLOGY

6. Established flight test techniques were used for the handling qualities and performance testing (refs 11 and 12, app A). Test methods are described briefly in the Results and Discussion section of this report. All tests were conducted under nonturbulent atmospheric conditions to preclude uncontrolled disturbances from influencing the test data. A detailed description of test instrumentation is contained in appendix C and a description of data reduction procedures in appendix D. Pilot comments were used to aid in the analysis of data and to determine the overall qualitative assessment of the flying qualities of the JOH-58A helicopter with an Allison 250-C20B engine installed. The Handling Qualities Rating Scale (HQRS) used to augment pilot qualitative comments is included as figure 1 in appendix D.

Table 1. Flight Test Conditions.[1]

Test	Density Altitude (ft)	Gross Weight (lb)	Center-of-Gravity Location[2] (in.)	Rotor Speed (rpm)	Calibrated Airspeed (kt)	Flight Mode
Hover performance	9760 to 10,400	3090 to 3310	107.2 to 107.6	354	Zero	IGE[3] (4-foot skid height)
	10,100 to 10,500	2865 to 3145	107.2 to 107.4	354	Zero	IGE (10-foot skid height)
	10,100 to 10,380	2860 to 2985	107.1 to 107.2	354	Zero	OGE[4] (50-foot skid height)
Vertical climb performance	1760 to 2360	2780 to 3180	106.8 to 107.4	348 to 351	Zero	Hover to 1200 ft/min
	4120 to 4860	2890 to 3240	107.1 to 108.0	348 to 351	Zero	Hover to 775 ft/min
Lateral acceleration	680	3180	107.8	354	Right, 36 KTAS[5] to left, 40 KTAS	Sideward
Low-speed flight characteristics	10,380	3060	107.2	355	Left, 36 KTAS to right, 32 KTAS	Sideward
	10,180	3010	107.1	354	Rearward, 32 KTAS to forward, 36 KTAS	Forward and rearward
Static droop characteristics	6340	2950	107.0	340 to 382	90	Climb[6], autorotation, climb[6]
	5160	2930	106.9		90	Level flight, climb[6], autorotation, level flight
	4400	2930	106.9		88	Level flight, climb[6], autorotation, level flight
Engine acceleration and deceleration	2260 to 7460	2990 to 3115	107.1 to 107.7	347 to 382	51 to 91	Level flight, climbs, descents, autorotation
Engine temperature survey	2200 to 7040	2890 to 3140	107.1 to 107.8	354	Zero to 90	Level flight, climbs, descents, autorotation
Engine vibration survey	2200 to 7040	2890 to 3140	107.1 to 107.8	354	Zero to 105	Level flight, climbs, autorotations, descents, turns

[1]Configuration: Clean, doors on.
[2]All cg locations forward.
[3]IGE: In ground effect.
[4]OGE: Out of ground effect.
[5]KTAS: Knots true airspeed.
[6]Climb at maximum power.

RESULTS AND DISCUSSION

GENERAL

7. A limited performance and handling qualities evaluation of the OH-58A helicopter with an Allison 250-C20B engine installed was conducted by USAAEFA. Performance, handling qualities, engine/airframe characteristics, and miscellaneous engineering tests were evaluated under a limited variety of operating conditions, with emphasis on operations near the military maximum gross weight of 3200 pounds. Primary performance improvement over the standard T63-A-700 engine was an increase in OGE hover ceiling from 4600 to 11,050 feet standard-day density altitude at a gross weight of 3000 pounds. Handling qualities were evaluated during low-speed and lateral accelerating flight. The OH-58A helicopter with the T63-A-700 engine is normally power limited, which prevents the accomplishment of certain maneuvers at heavy gross weights with hot-day conditions. The installation of the Allison 250-C20B engine increased the helicopter's capability, but full utilization of its maximum gross weight capability is still not possible, due to the inadequate handling qualities. One deficiency and five shortcomings were found. The deficiency was the considerable pilot compensation required to maintain aircraft control with SCAS OFF in left lateral accelerating flight. A SCAS is not installed in the standard OH-58A helicopter. Handling qualities shortcomings consisted of (1) insufficient left directional control in right sideward flight, (2) insufficient aft cyclic control in rearward flight, (3) extensive pilot compensation required in left sideward flight, (4) moderate pilot compensation required to maintain right lateral accelerating flight, and (5) the unsatisfactory governing characteristics of the OH-58A helicopter equipped with an Allison 250-C20B engine. These unsatisfactory handling qualities characteristics are inherent to the basic OH-58A helicopter and are not associated with the installation of the 250-C20B engine. The engine/airframe compatibility characteristics (cooling and vibration levels) of the OH-58A helicopter with the 250-C20B engine are similar to the standard OH-58A helicopter with the T63-A-700 engine.

PERFORMANCE

General

8. Performance testing of the OH-58A helicopter with an Allison 250-C20B engine was conducted at a hover, in vertical climbs, and in lateral accelerating flight. Hover test results were compared to results obtained with the previously tested T63-A-700 and 250-C20 engines. The OGE hover ceiling was increased from 4600 feet with the T63-A-700 engine to 11,050 feet density altitude at a gross weight of 3000 pounds with the 250-C20B engine. Within the scope of the test, the hover performance characteristics of the OH-58A helicopter with an Allison 250-C20B engine are greatly enhanced over the basic OH-58A helicopter.

FIGURE A

OGE HOVER CEILING

MODEL 250-C20B AND T63-A-700 ENGINES

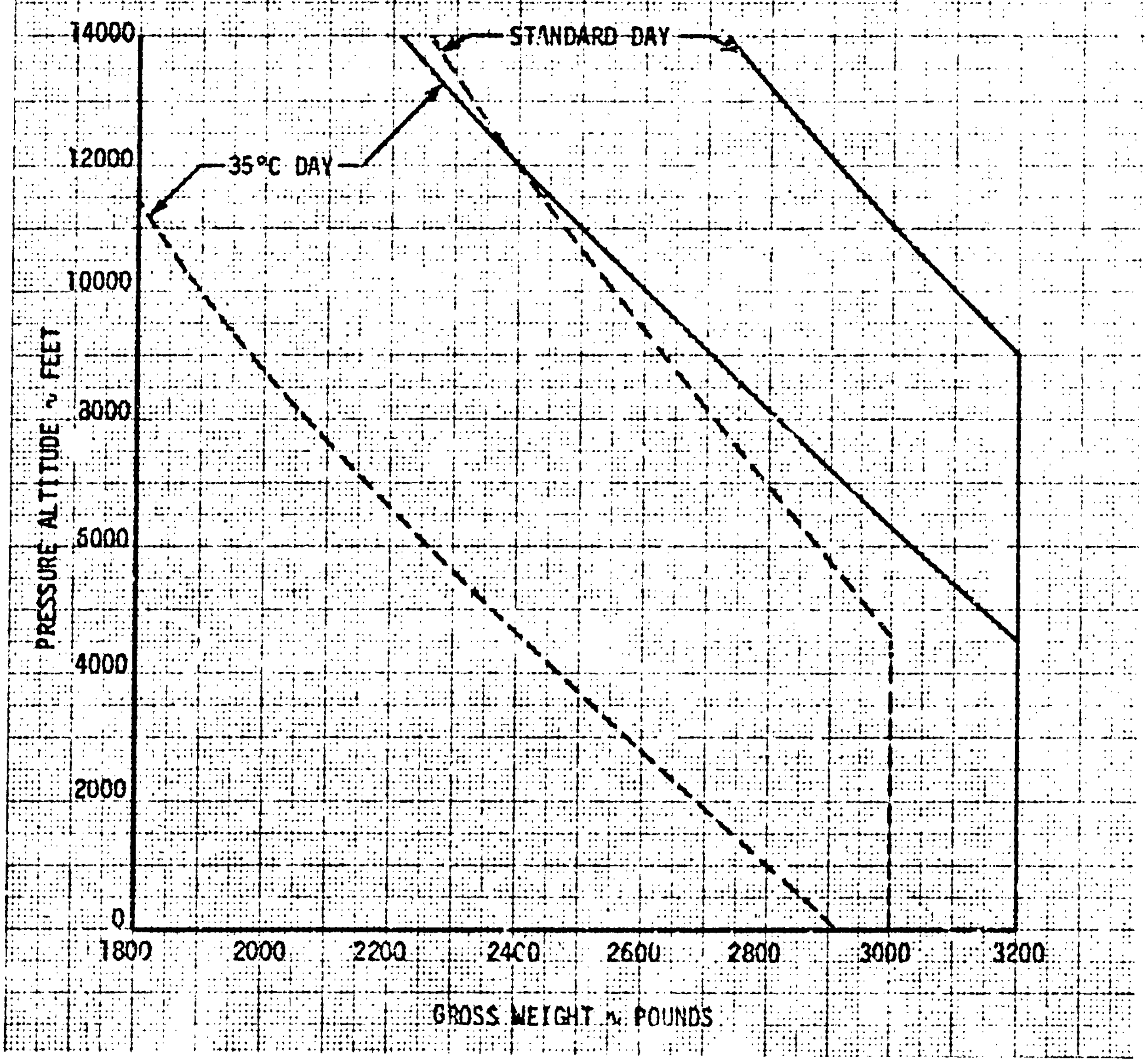
OH-58A HELICOPTER

354 MAIN ROTOR RPM

NOTE: 1. SOLID LINES DENOTE 250-C20B ENGINE AND DASHED LINES DENOTE T63-A-700 ENGINE

2. MAXIMUM GROSS WEIGHT LIMIT OF 3000 POUNDS FROM OPERATOR'S MANUAL FOR OH-58A HELICOPTER

3. MAXIMUM GROSS WEIGHT LIMIT OF 3200 POUNDS FROM SAFETY OF FLIGHT RELEASE FOR THE OH-58A WHEN CONFIGURED WITH AN ALLISON 250-C20B ENGINE



Hover Performance

9. Hover performance tests were conducted at skid heights of 4 and 10 feet IGE and 50 feet OGE under the conditions shown in table 1. The free-flight hover method was used to determine hover performance. Skid height was measured by visual reference to a measured weighted cord attached to the left skid. Incremental amounts of ballast were added to the helicopter until the gross weight was such that either the engine temperature or transmission power limit was reached. Test results are presented, together with T63-A-700 and 250-C20 hover data, in figures 1 through 3, appendix E. A comparison of the standard-day and 35°C hot-day OGE hover performance with the 250-C20B and T63-A-700 engines is presented in figure A. The OGE hover ceiling was increased from 4600 feet for the T63-A-700 engine and 10,000 feet for the 250-C20 engine to 11,050 feet for the 250-C20B engine. The increased hover performance of the OH-58A helicopter with the 250-C20B engine enhances its operational capability. Within the scope of the test, the hover performance of the OH-58A helicopter with the 250-C20B engine is improved over the basic OH-58A helicopter.

Vertical Climb Performance

10. Vertical climbs (zero horizontal airspeed) of approximately 20 seconds duration were made from an OGE hover at various constant collective control settings at the conditions shown in table 1. A radar altimeter was used to measure the rates of climb and an Elliott low-airspeed system was used to aid the pilot in maintaining zero horizontal airspeed while in a vertical climb. The vertical rate of climb for a given power increment was defined as that portion of the climb after the aircraft has achieved a steady unaccelerated rate-of-climb condition. Vertical climb testing had not been previously performed on the OH-58A helicopter, which precluded any comparison. A detailed description of the test techniques and data analysis methods used is contained in appendix D. To ensure hover data validity, the test hover power required was compared with the OGE hover performance data for the OH-58A helicopter and the results are presented in figure 3, appendix E. Test results are presented in figures 4 through 9. At 3200 pounds gross weight and standard-day, sea-level conditions, the maximum vertical rate of climb was calculated to be 660 feet per minute. The rates of climb that were achieved ranged from approximately 50 to 1200 feet per minute.

Lateral Acceleration Performance

11. The lateral acceleration performance of the OH-58A helicopter was evaluated by conducting lateral accelerations OGE (skid height approximately 50 feet) at the conditions shown in table 1. The lateral acceleration was accomplished by incrementally rolling the aircraft to a predetermined roll attitude (5-degree increments) with a rapid lateral control motion while maintaining constant skid height with power and maintaining a constant heading. A ground pace vehicle was used to determine limit sideward airspeed. Surface winds were less than 3 knots. Lateral flight performance data are presented in figure 10, appendix E.

12. The maximum roll attitude tested in right sideward flight was 18.4 degrees, at which point the never-exceed transmission torque pressure limit of 106 psi was inadvertently exceeded, which terminated further testing. The operational transmission torque pressure limit (92 psi) was reached repeatedly at roll attitudes greater than 10 degrees. In left sideward flight a maximum roll attitude of 16.7 degrees was achieved before termination of this test. Maximum acceleration achieved in left and right sideward flight was 11.2 and 13.9 feet per second per second (ft/sec^2), with a time to maximum acceleration of 7.5 and 5.3 seconds, respectively. Representative time histories for left and right accelerating flight are shown in figures 11 and 12, appendix E. There was no cue to alert the pilot of reaching limit sideward velocity (35 KTAS) other than the pilot's judgment of ground speed. Because of the lack of ground speed cues and the high probability of exceeding the transmission torque limits in right lateral accelerating flight, this maneuver should be limited to roll attitudes of less than 9 degrees during further testing of the lateral flight maneuver. Maximum lateral acceleration capability of the aircraft could not be used because the transmission torque limit would have been exceeded.

HANDLING QUALITIES

General

13. A limited handling qualities evaluation of the OH-58A helicopter with an Allison 250-C20B engine was conducted under day visual flight conditions. Lateral acceleration and low-speed flight characteristics were evaluated under the conditions shown in table 1 and the results were compared to those obtained during the T63-A-700 and 250-C20 engine evaluation (refs 2 and 3, app A). One deficiency and five handling qualities shortcomings were noted. The deficiency determined was the pilot compensation required to maintain aircraft control in left lateral accelerating flight with SCAS OFF. The handling qualities of the OH-58A helicopter equipped with an Allison 250-C20B engine are similar to a standard OH-58A helicopter, except that the standard OH-58A helicopter does not have a SCAS.

Low-Speed Flight Characteristics

14. Low-speed flight tests were conducted to determine the hovering capability (IGE) of the OH-58A helicopter in winds of various speeds and azimuths. Wind azimuths of zero, 90, 180, and 270 degrees relative to the nose of the helicopter were used. Test results are presented in figures 13 and 14, appendix E.

15. Previous right sideward flight tests at a thrust coefficient (C_T) of 0.00343 resulted in a left pedal margin of 5 percent at 35 KTAS (ref 3, app A). Results of the test with the 250-C20 engine (ref 3) showed that at 35 KTAS, the directional control margin rapidly diminished with increased C_T's. With the 250-C20B engine at a C_T of 0.00416, the maximum airspeed in right sideward flight was 32 KTAS with no directional control margin. Directional control in right sideward flight failed to meet the requirements of paragraph 3.3.2 of MIL-H-8501A,

in that the 10-percent directional control power was not present at 35 KTAS. Within the scope of this test, the sideward flight characteristics are aggravated by the installation of the 250-C20B engine because of the increased gross weight and altitude capability. Minimum required lateral low-speed flight capability could not be achieved because of tail rotor performance and aircraft instability. Insufficient left directional control in right sideward flight is a shortcoming. Consideration should be given to upgrading tail rotor performance and installing a SCAS.

16. In left sideward flight with SCAS OFF, as previously reported (ref 2, app A), at airspeeds from 15 to 25 KTAS, the helicopter was directionally unstable, with yaw excursions of approximately 10 degrees which required extensive pilot compensation to maintain adequate directional control (HQRS 6). The extensive pilot compensation required during left sideward flight at 15 to 25 KTAS is a shortcoming.

17. In rearward flight at the conditions tested, the aircraft was limited to 32 KTAS because the longitudinal control limit was reached (fig. 14, app E). The requirements of paragraph 3.2.1 of MIL-H-8501A were not met, in that 10 percent of the control power was not available in 30-KTAS rearward flight. Insufficient aft longitudinal control in rearward flight is a shortcoming.

Lateral Acceleration Handling Qualities

18. The lateral acceleration handling qualities, with SCAS ON and OFF, were evaluated during the lateral acceleration performance testing at the conditions presented in table 1, using the methods outlined in paragraph 11. Lateral acceleration testing had not been previously conducted on the OH-58A helicopter. Representative time histories are shown in figures 11 and 12, appendix E. With SCAS ON, minimal pilot compensation was required in left lateral acceleration to maintain heading, roll attitude, and pitch attitude up to approximately 18 KTAS (HQRS 3). Extensive pilot compensation was required to maintain flight path, heading, and roll attitude between 18 and 21 KTAS (HQRS 6). After accelerating through 21 KTAS, flight path, heading, and roll attitude were easily controlled as the aircraft accelerated to the 35-knot limit sideward airspeed (HQRS 3). Lateral acceleration to the right required minimal pilot compensation to smoothly accelerate to limit airspeed at roll attitudes up to 10 degrees (HQRS 3). At angles greater than 10 degrees, moderate pilot compensation was required to maintain a constant heading (HQRS 4). The pilot's difficulty in maintaining heading occurred at approximately 2 to 5 seconds after initiation of rollover to roll attitudes greater than 10 degrees. Because of the moderate compensation required to maintain heading at higher roll attitudes, the pilot's attention was diverted to controlling the aircraft and the transmission torque limits were inadvertently exceeded (para 12) before pilot corrective action could be taken.

19. Representative lateral accelerations to the right and left were qualitatively evaluated with SCAS OFF. Roll attitudes of 10 degrees were used for this evaluation. Lateral accelerations to the left required considerable pilot compensation to maintain a steady roll attitude and heading at airspeeds up to approximately

18 KTAS (HQRS 5). From 18 to 21 KTAS, considerable pilot compensation was required to retain control of the helicopter because of the severe roll and yaw excursions at these airspeeds (HQRS 8). These roll and yaw excursions precluded testing beyond 18 to 21 KTAS. Lateral accelerations to the right required moderate pilot compensation throughout the acceleration to maintain a constant heading and roll attitude (HQRS 4). The moderate pilot compensation required to maintain right lateral accelerating flight is a shortcoming, and the considerable pilot compensation required to maintain aircraft control during left lateral accelerating flight is a deficiency.

20. The addition of a SCAS improves the handling qualities of the OH-58A helicopter by reducing the severe yaw and roll excursions in left lateral acceleration sufficiently to allow accelerations through the 18- to 21-knot regime. Without inclusion of a SCAS the capability to perform lateral accelerations is considerably reduced. Extreme caution should be used if further testing is conducted at roll attitudes greater than 10 degrees. The following CAUTION should be incorporated in the operator's manual:

CAUTION

> Lateral accelerating flight to the left at roll attitudes greater than 10 degrees will result in severe roll and yaw excursions which make control of the aircraft difficult. Additionally, right lateral accelerating flight at roll attitudes greater than 10 degrees may easily result in transmission overtorque.

SUBSYSTEM TESTS

Engine Characteristics

21. Engine characteristics of the Allison 250-C20B engine, including power available and fuel flow, were determined from Allison Computer Source Deck 847. Power required was calculated using the torquemeter calibration performed by Allison. Referred engine characteristics are presented in figures 15 through 20, appendix E. Engine shp available and specification fuel flow are shown in figures 21 through 24. Inlet and exhaust losses were determined from data previously obtained with the T63-A-700 engine (ref 1, app A).

Engine Vibration

22. Vibration data were gathered concurrently with performance and handling qualities tests. Vibration sensors were installed at the following engine locations: compressor section, gearbox, turbine and combustion section, top engine mount pad, and fuel nozzle, as called out in Allison Installation Design Manual No. 10W5 (ref 5, app A). Tail rotor gearbox vibration levels were also monitored throughout the evaluation.

23. The vibration data were compared to the installed engine vibration limits specified on the installation drawing. The vibration characteristics at all the specified locations will not be discussed in detail but, in general, show the presence of low- and moderate-amplitude low-frequency vibration levels (10 to 2000 Hz) at all of the accelerometer locations. Results are shown in tabular form in figures 25 through 27, appendix E. Maximum acceleration values below 10 percent of the maximum limit value specified by Allison were not presented. All the vibration levels were within Allison's specified limits. The maximum average acceleration measured for the tail rotor gearbox was 1.8g at 1720 Hz in an IGE hover.

Engine Compartment Temperature Survey

24. A limited engine compartment temperature survey was performed during the evaluation. Temperatures were recorded at locations specified in Allison Installation Design Manual No. 10W5. The temperature probes were located at the following locations: compressor section, top engine mount pad surface, ignition harness, thermocouple harness, and oil cooler. Temperature data for all conditions tested are presented in figure 28, appendix E. When the component/fluid temperature data are corrected to the Army's design requirement maximum ambient temperature of 125°F (52°C), an overtemperature condition is indicated for the oil cooler outlet temperature, as is shown in figure 28. The temperature data were corrected by the following equation:

$$T = T_{measured} \frac{52 + 273}{T_{ambient} + 273}$$

(all temperatures are in degrees Centigrade)

The effect of altitude-temperature variation was not determined. Within the scope of this evaluation, the engine compartment cooling was satisfactory, but correcting the engine oil cooler temperature to 125°F ambient temperature indicates the oil cooler temperature would not be adequate.

Engine Governing Characteristics

25. Static and dynamic droop characteristics of the Allison 250-C20B engine governor were evaluated under the conditions listed in table 1. Test results are presented in figures 29 through 48, appendix E. Dynamic stability characteristics of the 250-C20B engine were qualitatively and quantitatively investigated. No compressor stalls were experienced even with large rapid power demands. There were no undamped engine oscillating tendencies (figs. 29 through 32). There were no undamped engine oscillating tendencies (figs. 27 through 30), although the torque pressure was lightly damped, with a damping ratio of 0.06 at a damped frequency of 2.86 cycles per second. Dynamic stability characteristics were satisfactory throughout the flight envelope tested.

26. The tests specified for the applicable sections of MIL-T-25920B (USAF) were performed to demonstrate suitability of the ground and flight operational and

performance characteristics of the propulsion system of the aircraft installation (figs. 33 through 47, app E). Constant manipulation of the power turbine speed-select "beep" switch was required to maintain a desired rotor speed during power changes. This characteristic is the result of poor static droop characteristics and is shown in figure 48. From a normal stabilized flight condition of 45 psi engine torque and a rotor speed of 354 rpm, application of collective control caused rotor speed variation from 348 rpm during power increases to 362 rpm during power decreases. Returning to the trim power setting resulted in a permanent rotor speed droop of 6 rpm, which is within 1 rpm of the minimum power-on rotor speed. The static rpm droop characteristics of the 250-C20B engine/airframe combination (the change in rotor speed versus engine power output) were objectionable for all flight conditions tested (fig. 48). The engine governing characteristics are a shortcoming.

CONCLUSIONS

GENERAL

27. The following conclusions were reached upon completion of the Allison 250-C20B engine evaluation:

a. Within the scope of this test, the performance of the OH-58A helicopter with an Allison 250-C20B engine was improved over the basic OH-58A helicopter, while the handling qualities were essentially unchanged.

b. The OGE hover ceiling at 3000 pounds gross weight was increased to 11,050 feet.

c. The engine oil cooler temperature when corrected to 125°F ambient temperature indicates the oil cooler performance would not be adequate.

d. One deficiency and five shortcomings were noted.

DEFICIENCY AND SHORTCOMINGS

28. The following deficiency was identified: Considerable pilot compensation required to maintain aircraft control in left lateral accelerating flight (para 18).

29. The following shortcomings were identified:

a. Insufficient left pedal in right sideward flight at 32 KTAS (para 15).

b. Extensive pilot compensation required to maintain left sideward flight (para 16).

c. Insufficient aft cyclic control in rearward flight at 30 KTAS (para 17).

d. Moderate pilot compensation required to maintain right accelerating flight (para 19).

e. Objectionable engine governing characteristics of the OH-58A helicopter with an Allison 250-C20B engine (para 26).

SPECIFICATION COMPLIANCE

30. Within the scope of this test, the OH-58A helicopter with an Allison 250-C20B engine installed failed to meet the requirements of paragraphs 3.2.1 and 3.3.2 of MIL-H-8501A, in that sufficient aft cyclic control was not available during 30-KTAS rearward flight and sufficient left directional control was not available during 35-KTAS right sideward flight (paras 17 and 15).

RECOMMENDATIONS

31. The deficiency identified during this evaluation should be corrected before the OH-58A helicopter is released to perform the lateral acceleration maneuver at roll attitudes greater than 10 degrees (para 18).

32. The shortcomings should be corrected.

33. The following CAUTION should be incorporated in the applicable sections of the operator's manual:

CAUTION

> Lateral accelerating flight to the left at roll attitudes greater than 10 degrees will result in severe roll and yaw excursions which make control of the aircraft difficult. Additionally, right lateral accelerating flight at roll attitudes greater than 10 degrees may easily result in transmission overtorque.

34. An improved tail rotor should be installed to increase the operational capability of the OH-58A helicopter when equipped with a 250-C20B engine.

35. A SCAS should be provided with both lateral and directional axes to improve the low-speed and lateral flight capability of the aircraft (paras 15 and 20).

APPENDIX A. REFERENCES

1. Final Report, USAASTA, Project No. 68-30, *Airworthiness and Flight Characteristics Test, Production OH-58A Helicopter, Unarmed and Armed with the XM27E1 Weapons System, Performance*, September 1970.

2. Final Report, USAASTA, Project No. 68-30, *Airworthiness and Flight Characteristics Test, Production OH-58A Helicopter, Unarmed and Armed with the MX27E1 Weapons System, Stability and Control*, October 1970.

3. Final Report, USAASTA, Project No. 71-24, *Evaluation of the OH-58A Helicopter with an Allison 250-C20 Engine*, December 1972.

4. Letter, AVSCOM, AMSAV-EFT, 14 June 1974, subject: Evaluation of the OH-58A Helicopter with the Allison 250-C20B Engine Installed, Project No. 74-48.

5. Installation Design Manual, Detroit Diesel Allison Division of General Motors Corporation, No. 10W5, *Commercial Turboshaft Engine, Model 250-C20B*, 12 March 1974.

6. Final Report, USAASTA, Project No. 72-20, *Handling Qualities Evaluation of the OH-58A Helicopter Incorporating the Model 570B Stability and Control Augmentation System*, February 1973.

7. Technical Manual, TM 55-1520-228-10, *Operator's Manual, Army Model OH-58A Helicopter*, 13 October 1970.

8. Letter, AVSCOM, AMSAV-EFT, 4 October 1974, subject: Safety of Flight Release for AVSCOM/USAAEFA Project No. 74-48.

9. Military Specification, MIL-H-8501A, *Helicopter Flying and Ground Handling Qualities; General Requirements For*, September 1961, with Amendment 1, 3 April 1962.

10. Military Specification, MIL-T-25920B (USAF), *Test, Ground and Flight, Aircraft Gas Turbine Propulsion System Installation*, 10 February 1966.

11. Flight Test Manual, Naval Air Test Center, FTM No. 101, *Helicopter Stability and Control*, 10 June 1968.

12. Flight Test Manual, Naval Air Test Center, FTM No. 102, *Helicopter Performance Testing*, 28 June 1968.

13. Final Report, USAAEFA, Project No. 68-55, *Flight Evaluation, Compliance Test Techniques for Army Hot Day Hover Criteria*, April 1974.

14. Final Report, USAAEFA, Project No. 68-25, *Flight Research Investigation of Autorotational Performance and Height-Velocity Testing*, in preparation.

APPENDIX B. GENERAL ENGINE INFORMATION

GENERAL

1. The Allison Model 250-C20B engine is an internal combustion turboshaft engine of the free turbine type. The gas producer is composed of a combination six-stage axial single-stage centrifugal flow compressor directly coupled to a two-stage turbine. The power turbine is a two-stage free turbine that is gas coupled to the gas producer turbine. The integral reduction gearbox provides an internal spline output drive at the front of the gearbox. The engine has a single combustion chamber. The output shaft center line is located below the center line of the engine rotor and the exhaust is directed upward. The performance rating for the uninstalled standard-day static sea-level conditions is shown in table 1.

COMPRESSOR

2. The compressor assembly consists of a compressor front support, case assembly, rotor wheels with blades, centrifugal impeller, front diffuser assembly, rear diffuser assembly, diffuser vane assembly, and diffuser scroll. Air enters the engine through the compressor inlet and is compressed by six axial compressor stages and one centrifugal stage. The compressed air is discharged through the scroll-type diffuser into two external ducts which convey the air to the combustion section, as shown in figure 1.

COMBUSTION SECTION

3. The combustion section consists of the outer combustion case and the combustion liner. A spark igniter and a fuel nozzle are mounted in the aft end of the outer combustion case. Air enters the single combustion liner at the aft end through holes in the liner's dome and skin. The air is mixed with fuel sprayed from the fuel nozzle and combustion takes place. Combustion gases move forward out of the combustion liner to the first-stage gas producer turbine nozzle.

TURBINE

4. The turbine consists of a gas producer turbine support, a power turbine support, a turbine and exhaust collector support, a gas producer turbine rotor, and a power turbine rotor. The turbine is mounted between the combustion section and the power and accessory gearbox. The two-stage gas producer turbine drives the compressor and accessory gear train. The two-stage power turbine furnishes the output power of the engine. The expanded gas discharges in an upward direction through the twin ducts of the turbine and exhaust collector support.

Table 1. Engine Ratings at Standard Sea-Level Static Conditions.

Rating	Shaft Horsepower (shp)	Jet Thrust (lb)	Gas Producer Speed (rpm)	Output Shaft Speed (rpm)	Specific Fuel Consumption (lb/shp-hr)	Engine Output Torque (ft-lb)	Turbine Outlet Temperature (°C)
Takeoff (5 min)	420	42	53,000	6016	0.650	384	810
30-minute power	420	42	53,000	6016	0.650	384	810
Maximum continuous[1]	400	40	52,220	6016	0.648	349	779
Maximum cruise[2]	370	38	51,200	6016	0.650	323	738
Cruise A[3]	333	36	50,160	6016	0.665	323	697
Cruise B[3]	278	32	48,800	6016	0.709	323	646
Flight-idle	35 max	10	33,000	4500 to 6300	70 lb/hr	---	427 ±38
Autorotation	Zero	10	33,000	5900 to 6480	70 lb/hr	---	413 ±38

[1]Maximum continuous rating is authorized by the engine manufacturer only for aircraft certification and for emergency use.
[2]Maximum cruise is the highest power authorized by the engine manufacturer for normal continuous operation.
[3]Cruise A and Cruise B are the power lever positions that provide 90% and 75%, respectively, of the rated maximum cruise power at standard sea-level static conditions.

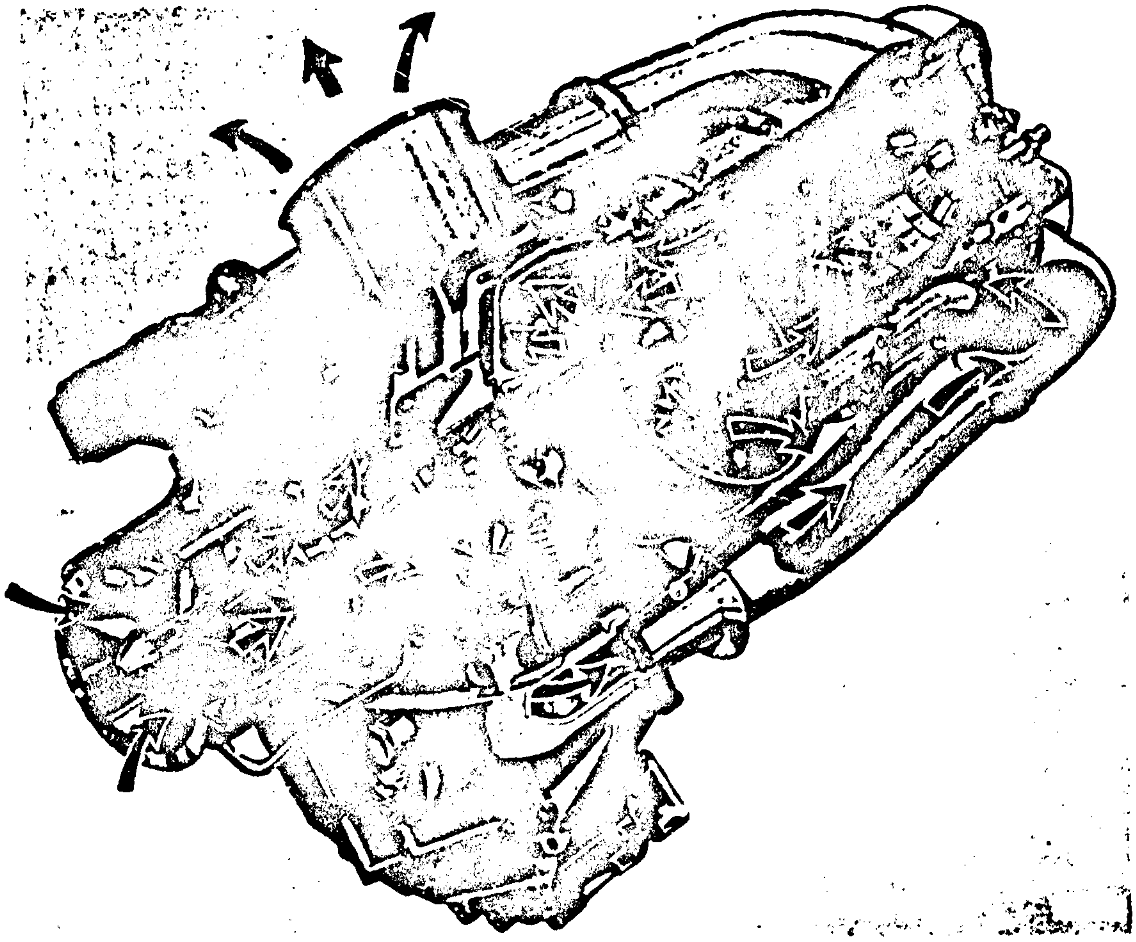


Figure 1. Allison 250-C20B Engine Cutaway.

POWER AND ACCESSORY GEARBOX

5. The main power and accessories drive gear trains are enclosed in a single gear case. The gear case serves as the stucture support of the engine. All engine components, including the engine-mounted accessories, are attached to the case. A two-stage helical and spur gear set is used to reduce rotational speed from 33,290 rpm at the power turbine to 6016 rpm at the output drive spline. Accessories driven by the power turbine gear train are the power turbine governor and an airframe furnished power turbine tachometer-generator. The gas producer gear train drives the compressor, fuel pump, gas producer fuel control, and an airframe furnished gas producer tachometer-generator. The starter drive and a spare drive are in this gear train.

FUEL SYSTEM

6. The principal components of the fuel system are a fuel pump, a gas producer fuel control, a power turbine governor, and a fuel nozzle. The fuel control and governor are located in the system between the fuel pump and the fuel nozzle. The engine can be equipped with either a Bendix or Chandler Evans (CECO) fuel system. The test aircraft was equipped with a Bendix fuel system.

APPENDIX C. INSTRUMENTATION

PILOT/ENGINEER PANEL

Airspeed (boom)
Altitude (boom)
Angle of sideslip
Rotor speed
Center-of-gravity normal acceleration
Free air temperature
Total fuel used
Longitudinal control position
Lateral control position
Directional control position
Collective control position
Turbine outlet temperature
Engine compartment temperatures
Engine torque
Gas producer speed
Engineer event marker
Record counter

MAGNETIC TAPE RECORDER

Longitudinal control position
Lateral control position
Directional control position
Collective control position
Pitch attitude
Roll attitude
Yaw attitude
Pitch rate
Roll rate
Yaw rate
Altitude (boom)
Airspeed (boom)
Altitude (radar)
Vertical speed (radar)
Free air temperature
Angle of sideslip
Center-of-gravity normal acceleration

Rotor speed
Throttle position
Engine torque
Gas producer speed
Engine vibration
Engine compartment temperatures
Fuel flow rate
Engine fuel nozzle pressure
Engineer event marker

APPENDIX D. TEST TECHNIQUES AND DATA ANALYSIS METHODS

1. This appendix contains some of the data reduction and analysis methods used to evaluate the OH-58A helicopter equipped with an Allison 250-C20B engine. The topics discussed include hover, vertical climb, and lateral flight performance.

2. The helicopter performance test data were generalized through the use of nondimensional coefficients. The purpose is to accurately obtain performance at conditions not specifically tested. The following nondimensional coefficients were used to generalize the hover and vertical climb test results obtained during this flight test program.

a. Coefficent of power (Cp):

$$C_P = \frac{SHP \times 550}{\rho A(\Omega R)^3} \qquad (1)$$

b. Coefficient of weight (C_W):

$$C_W = \frac{W}{\rho A(\Omega R)^2} \qquad (2)$$

During stabilized hover, coefficient of thrust equals coefficient of weight.

c. Vertical advance ratio:

$$\mu = \frac{Vv}{\Omega R} \qquad (3)$$

Where:

SHP = Engine output shaft horsepower

550 = Conversion factor (ft-lb/sec/shp)

ρ = Air density (lb-sec^2/ft^4)

A = Main rotor disc area (ft^2)

Ω = Main rotor angular velocity (rad/sec)

R = Main rotor radius

W = Gross weight (lb)

Vv = Vertical velocity (ft/sec)

3. Engine output shp was determined from the engine torque pressure. Torque pressure as a function of the power output of the engine was obtained from the engine manufacturer's test cell calibration. The shp required was determined by the following equation:

$$SHP = \frac{2\pi \times Kt \times GR \times N_R \times Q}{33{,}000}$$

Where:

SHP = Shaft horsepower

Kt = Conversion factor to change measured engine torque pressure (psi) to ft-lb (from contractor's engine acceptance data)

GR = Gear ratio of the output shaft rotational speed to the main rotor rotational speed

N_R = Main rotor speed (rpm)

Q = Engine torque pressure (psi)

33,000 = Conversion factor (ft-lb/min per shp)

HOVER

4. Hover performance was determined IGE and OGE by the free-flight hover technique. Formulas 1 and 2 were used to define the hover capability. A plot of C_P versus C_T was constructed for each skid height tested. Hover performance characteristics may be extracted from these curves in preparing tables or curves for flight manuals for any combination of conditions.

VERTICAL CLIMB

5. The vertical climb technique used by the pilot was to stabilize in a 50-foot OGE hover and then to increase engine power by a predetermined increment of gas producer speed (N_1) over the hover N_1 speed to the transmission torque limit. Two cues were used by the pilot to maintain vertical climbing flight. An Elliott low-airspeed sensor sensitive to 1 knot in horizontal airspeed was used to provide cues of lateral translation during the climb. To provide cues to any forward or aft movement, the pilot used a narrow taxiway as a visual reference.

6. Vertical climb performance was determined by using equations 1, 2, and 3. Each vertical climb was flown at a predetermined W/δ and $N/\sqrt{\theta}$. To maintain

W/δ approximately constant, the aircraft was periodically reballasted as fuel was consumed. $N/\sqrt{\theta}$ was held constant by increasing or decreasing rotor speed as the ambient air temperature increased or decreased, respectively.

7. The climb rates were measured after the aircraft was stabilized in a nonaccelerating vertical climb by means of a radar altimeter. The initial rate of climb (dh/dt) was corrected to tapeline rate of climb (R/C_T) by the equation:

$$R/C_T = \frac{dh}{dt} \frac{Ta_t}{Ta_s}$$

Where:

Ta_t = Test ambient air temperature (°K)

Ta_s = Standard ambient air temperature (°K)

8. The standard rate of climb was determined by correcting the tapeline rate of climb for gross weight differences and by the power-energy equation for nonsteady flight conditions. The adjusted momentum theory discussed in reference 13, appendix A, was used to facilitate curve fairing. A power adjustment factor (K_S) of 3.5 and equivalent flat plate area of 50 square feet were found to adequately fit all data sets.

9. After the raw data were reduced to calibrated engineering units, it was presented in referred terms of $SHP/\delta\sqrt{\theta}$, $V_V/\sqrt{\theta}$, W/δ, and $N_R/\sqrt{\theta}$. For convenience the test data were also presented in dimensionless parameters, C_P, C_W, and μ_V. Vertical climb performance characteristics may be extracted from these curves in preparing tables or curves for flight manuals or further engineering evaluation for any combination of conditions.

LATERAL FLIGHT PERFORMANCE

10. Lateral flight performance characteristics data were reduced from parameters recorded on board the aircraft. The test helicopter was equipped with aircraft (body) axis accelerometers and by measuring Euler angles, it was possible to transform the aircraft axis accelerations into earth (ground) axis accelerations. This made it possible to measure the lateral aircraft acceleration without the use of space positioning equipment. A detailed explanation of this technique can be found in reference 14, appendix A.

11. The HQRS presented as figure 1 was used to augment pilot comments relative to handling qualities.

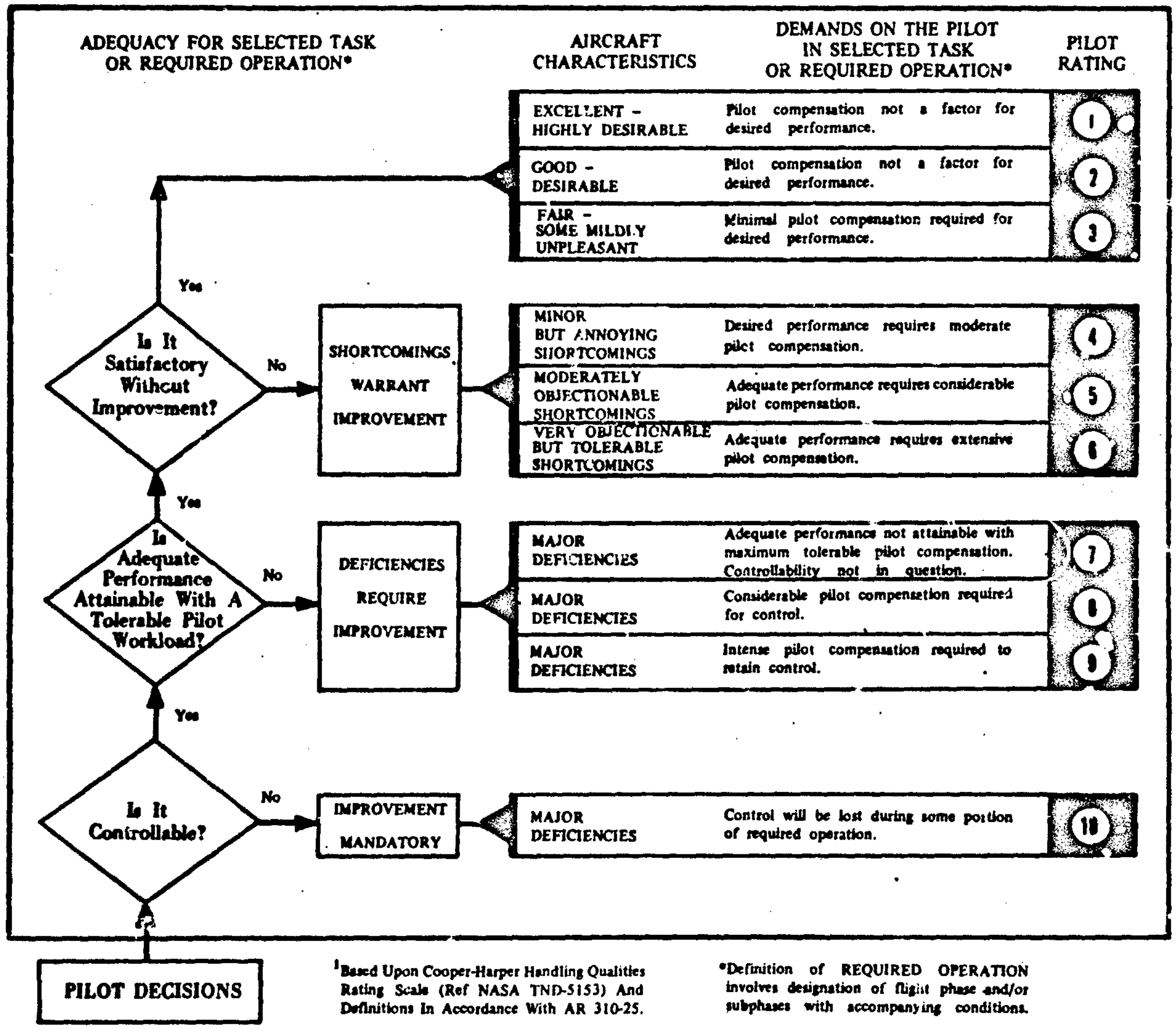
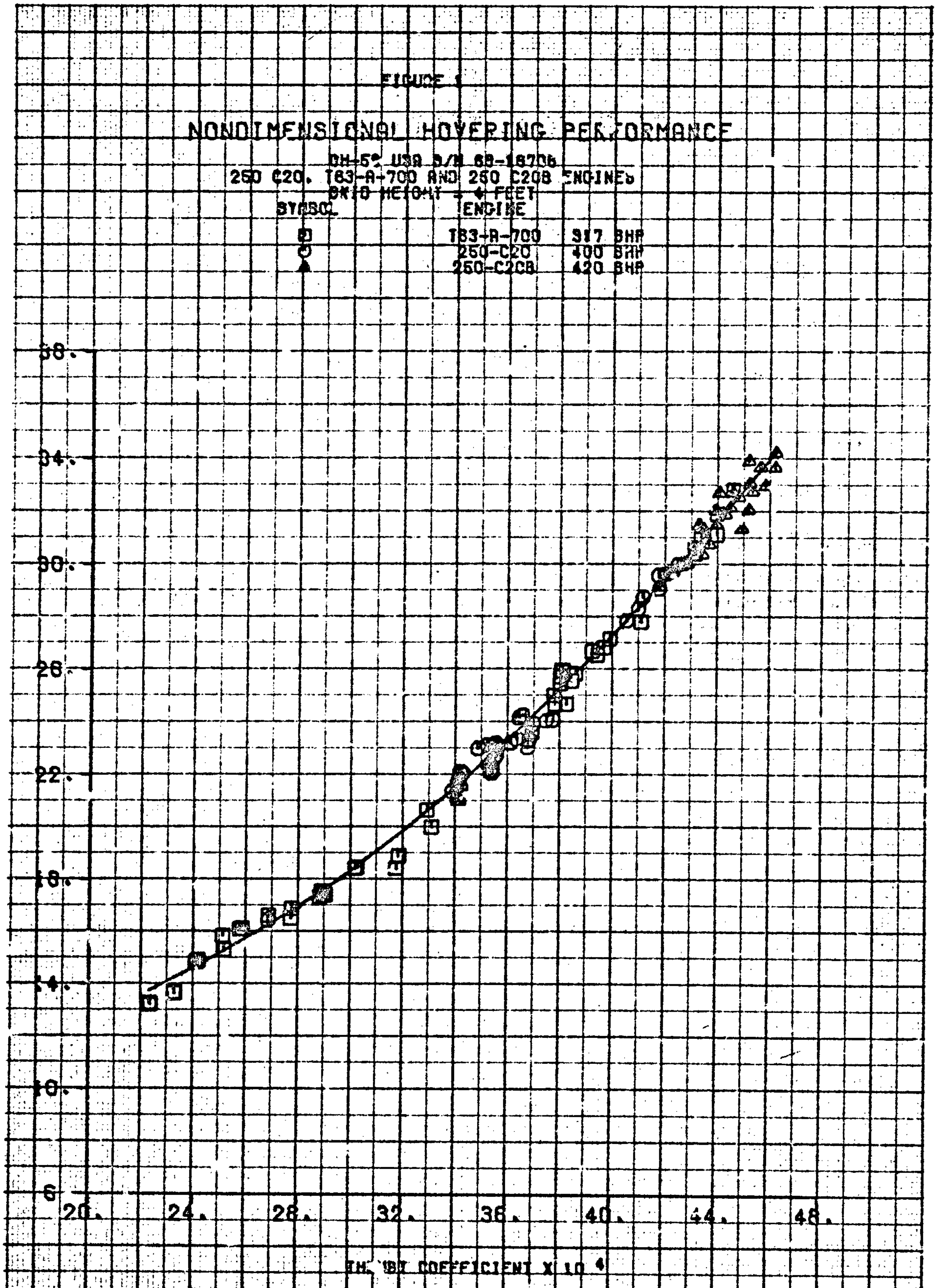


Figure 1. Handling Qualities Rating Scale.

APPENDIX E. TEST DATA

INDEX

Figure	Figure Number
Performance	
Hover	1 through 3
Vertical Climb	4 through 9
Lateral Acceleration	10 through 12
Handling Qualities	
Low-Speed Flight Characteristics	13 and 14
Subsystem Tests	
Engine Characteristics	15 through 24
Engine Vibration	25 through 27
Engine Compartment Temperature	28
Engine Governing Characteristics	29 through 48



NONDIMENSIONAL HOVERING PERFORMANCE
250 C20, T63-A-700 AND 250 C20B ENGINES
SYMBOL
ENGINE
T63-A-700
250-C20
400 BHP
420 BHP
38.
34.
30.
26.
22.
18.
14.
10.
6
20.
24.
28.
32.
36.
40.
44.
48.
COEFFICIENT X 10 4

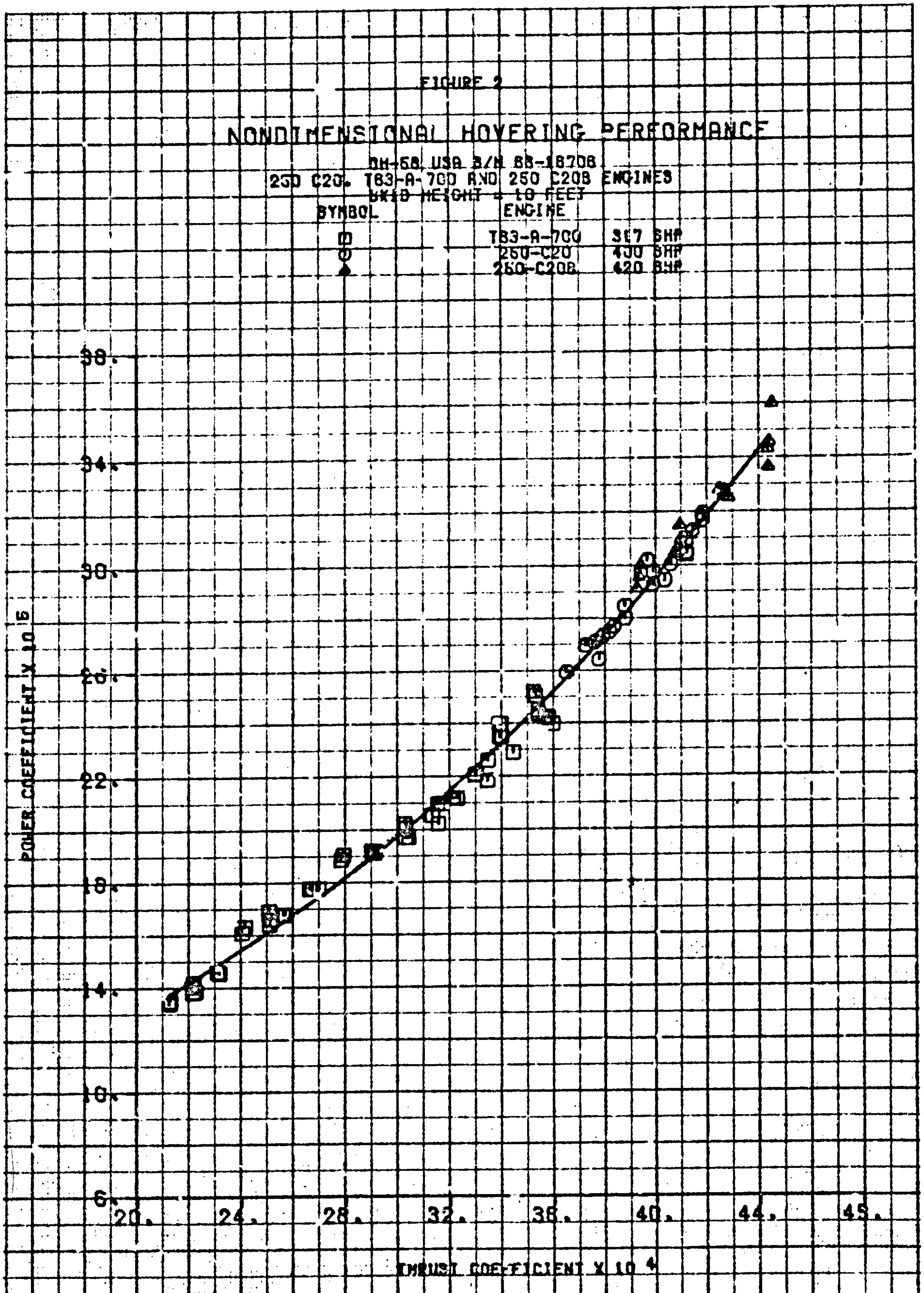


FIGURE 2
NONDIMENSIONAL HOVERING PERFORMANCE
OH-58 USA S/N 68-16708
250 C20, T63-A-700 AND 250 C20B ENGINES
SKID HEIGHT = 10 FEET
SYMBOL
ENGINE
T63-A-700 317 SHP
250-C20 400 SHP
250-C20B 420 SHP
POWER COEFFICIENT X 10 6
THRUST COEFFICIENT X 10 4
6.
10.
14.
18.
22.
26.
30.
34.
38.
20.
24.
28.
32.
36.
40.
44.
48.

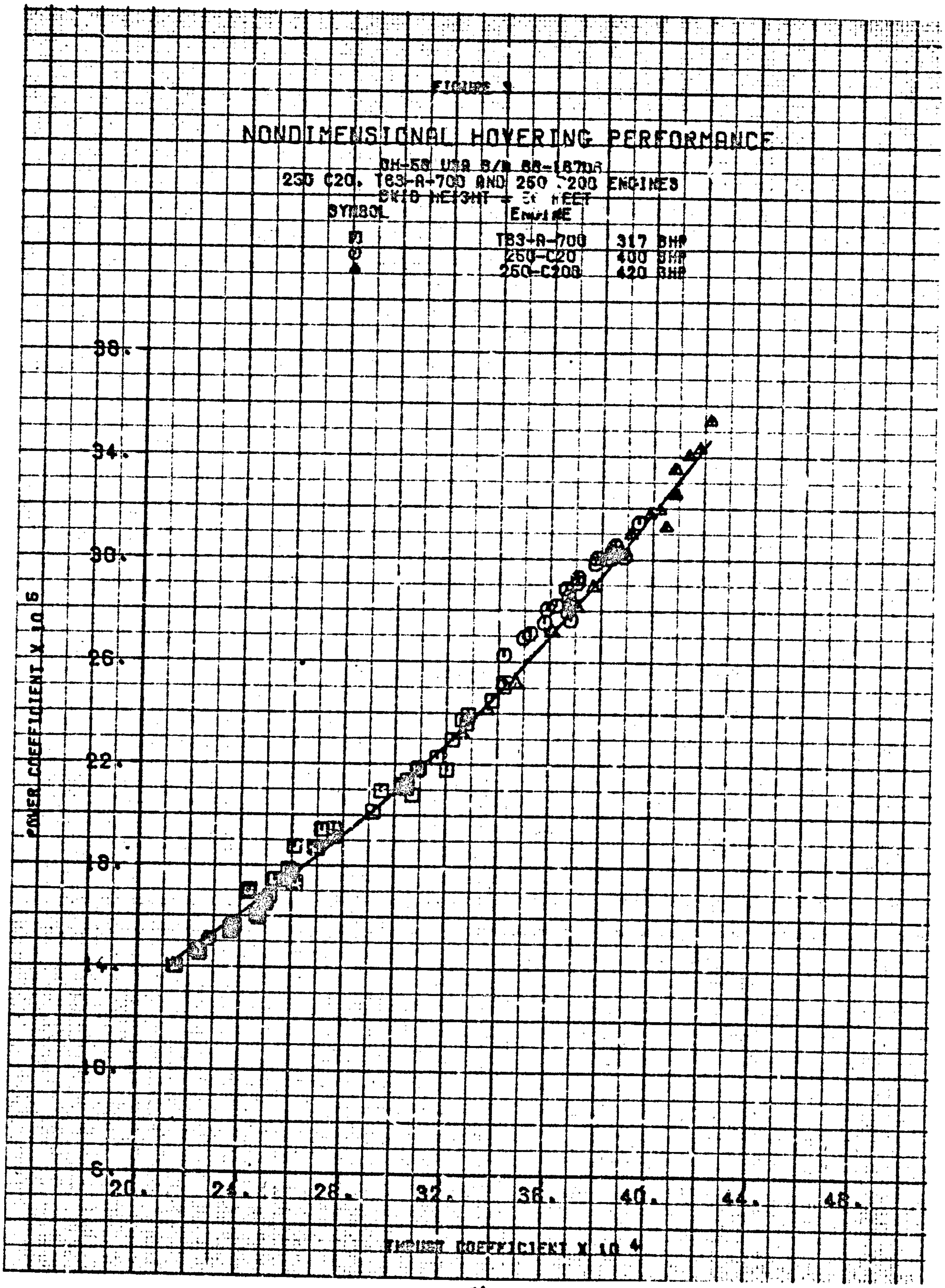

NONDIMENSIONAL HOVERING PERFORMANCE
250 C20, T63-A-700 AND 250 C20B ENGINES
SYMBOL
ENGINE
T63-A-700 317 BHP
250-C20 400 BHP
250-C20B 420 BHP
POWER COEFFICIENT X 10 5
38.
34.
30.
26.
22.
18.
14.
10.
6.
20.
24.
28.
32.
36.
40.
44.
48.
THRUST COEFFICIENT X 10 4

FIGURE 4
VERTICAL CLIMB PERFORMANCE
OH-58A USA S/N 68-16706
MODEL 250-C20B ENGINE

SYMBOL	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
⊙	2780	107.1(FWD)	2360	10.5	351	0.00303
⊡	2880	107.4(FWD)	2280	9.0	350	0.00315
◇	2980	106.8(FWD)	2380	7.0	349	0.00326
△	3080	107.0(FWD)	1780	5.5	348	0.00336
◁	2890	107.3(FWD)	4520	11.0	351	0.00336

NOTES: 1. CONFIGURATION CLEAN - DOORS ON.
2. REFERRED ROTOR SPEED - $N/\sqrt{\theta}$ = 354.

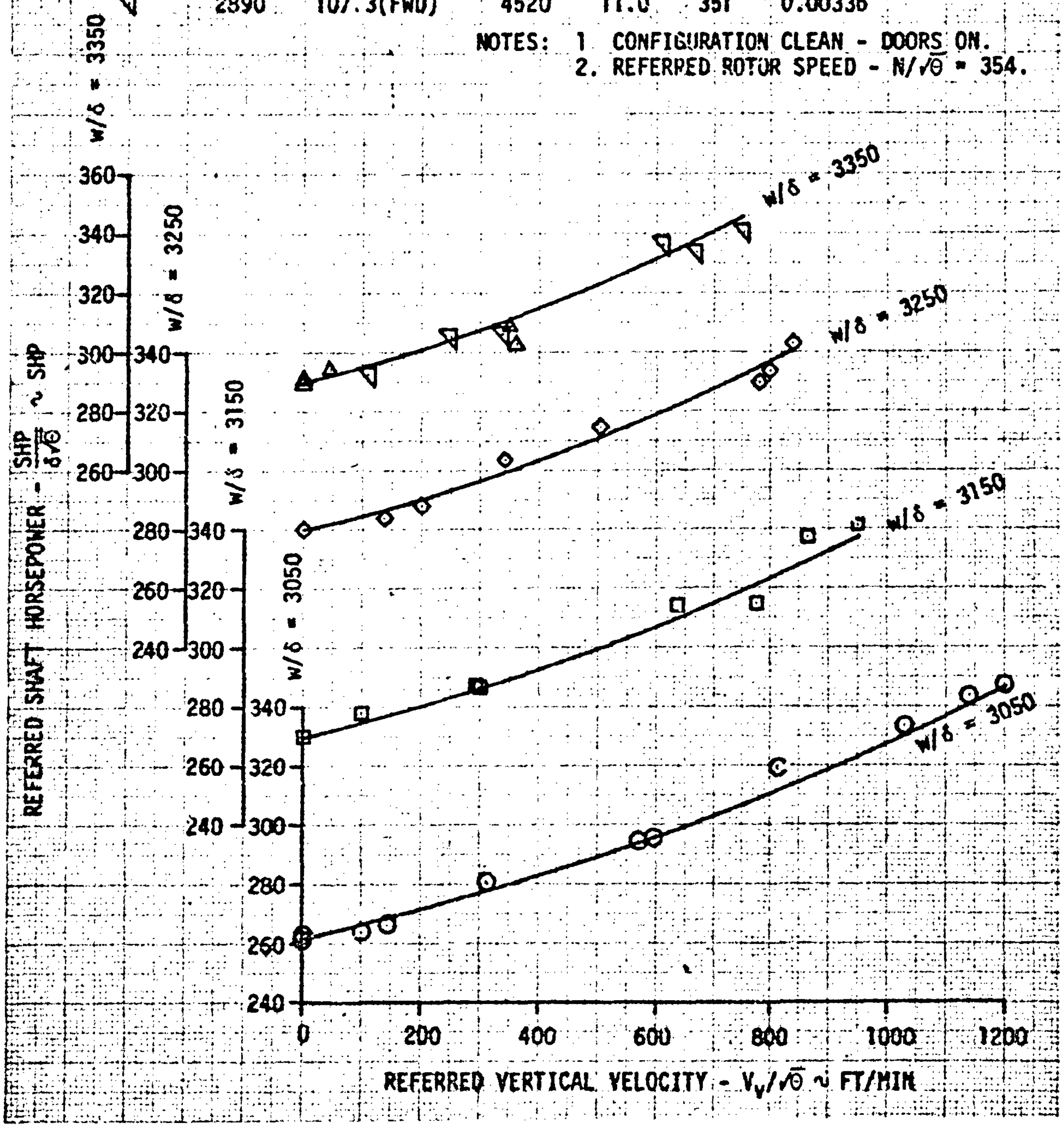


FIGURE 5
VERTICAL CLIMB PERFORMANCE
OH-58A USA S/N 68-16706
MODEL 250-C20B ENGINE

SYMBOL	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
▽	3180	107.2(FWD)	1760	6.0	348	0.00347
◁	2950	107.3(FWD)	4860	11.0	351	0.00347
⊙	3090	107.1(FWD)	4120	5.5	348	0.00361
⬭	3180	107.7(FWD)	4460	8.5	350	0.00371
θ	3240	108.0(FWD)	4340	8.0	350	0.00377

NOTES: 1. CONFIGURATION CLEAN - DOORS ON.
2. REFERRED ROTOR SPEED - $N/\sqrt{\theta}$ = 354.

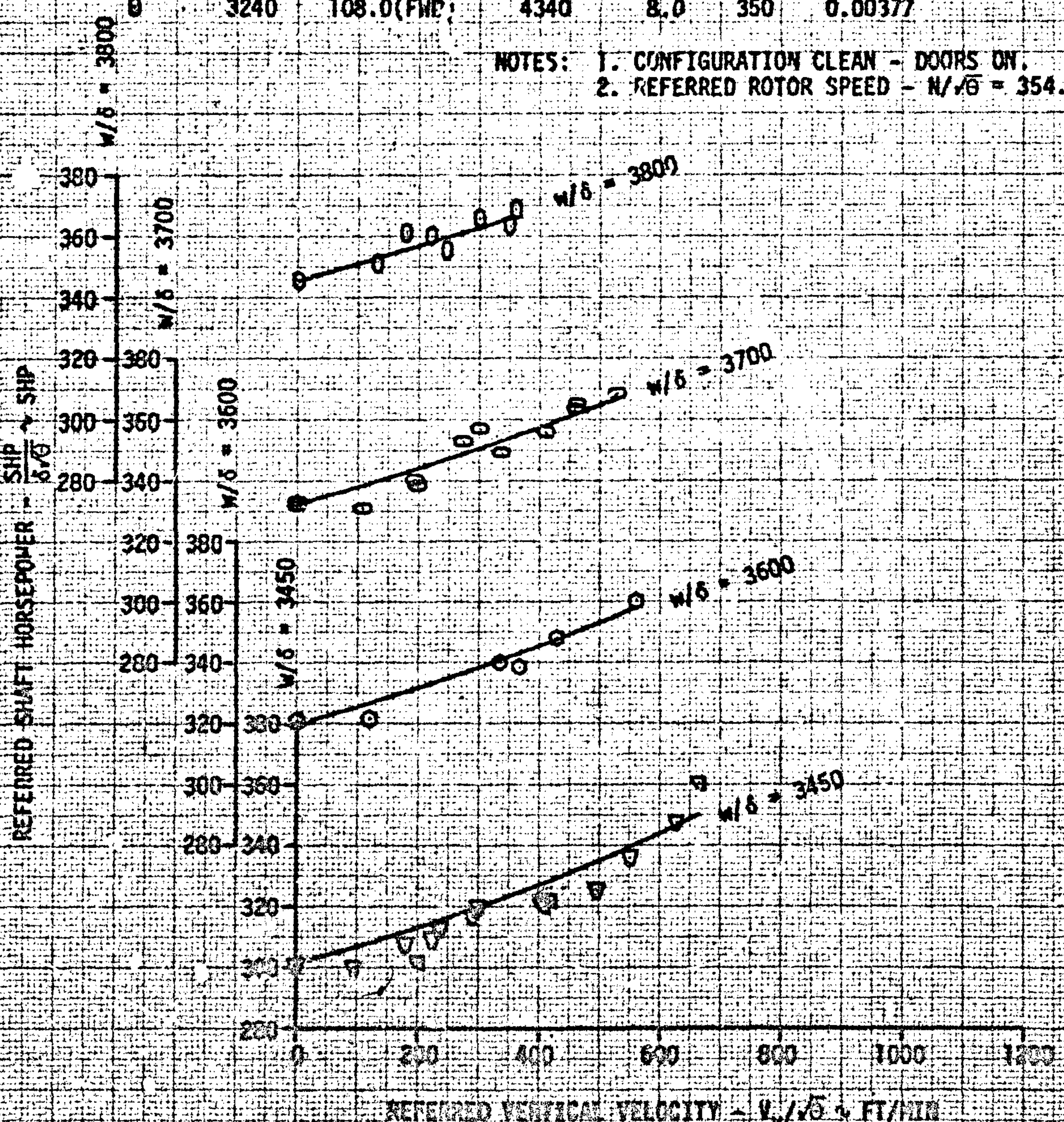


FIGURE 6
VERTICAL CLIMB PERFORMANCE
OH-58A USA S/N 68-16706
MODEL 250-C20B ENGINE

NOTES:
1. CONFIGURATION CLEAN - DOORS ON.
2. REFERRED ROTOR SPEED - $N/\sqrt{\theta}$ = 354.
3. DERIVED FROM FIGURES 4 AND 5.
4. REFERRED VERTICAL VELOCITY ($V_V/\sqrt{\theta}$) - FT/MIN.

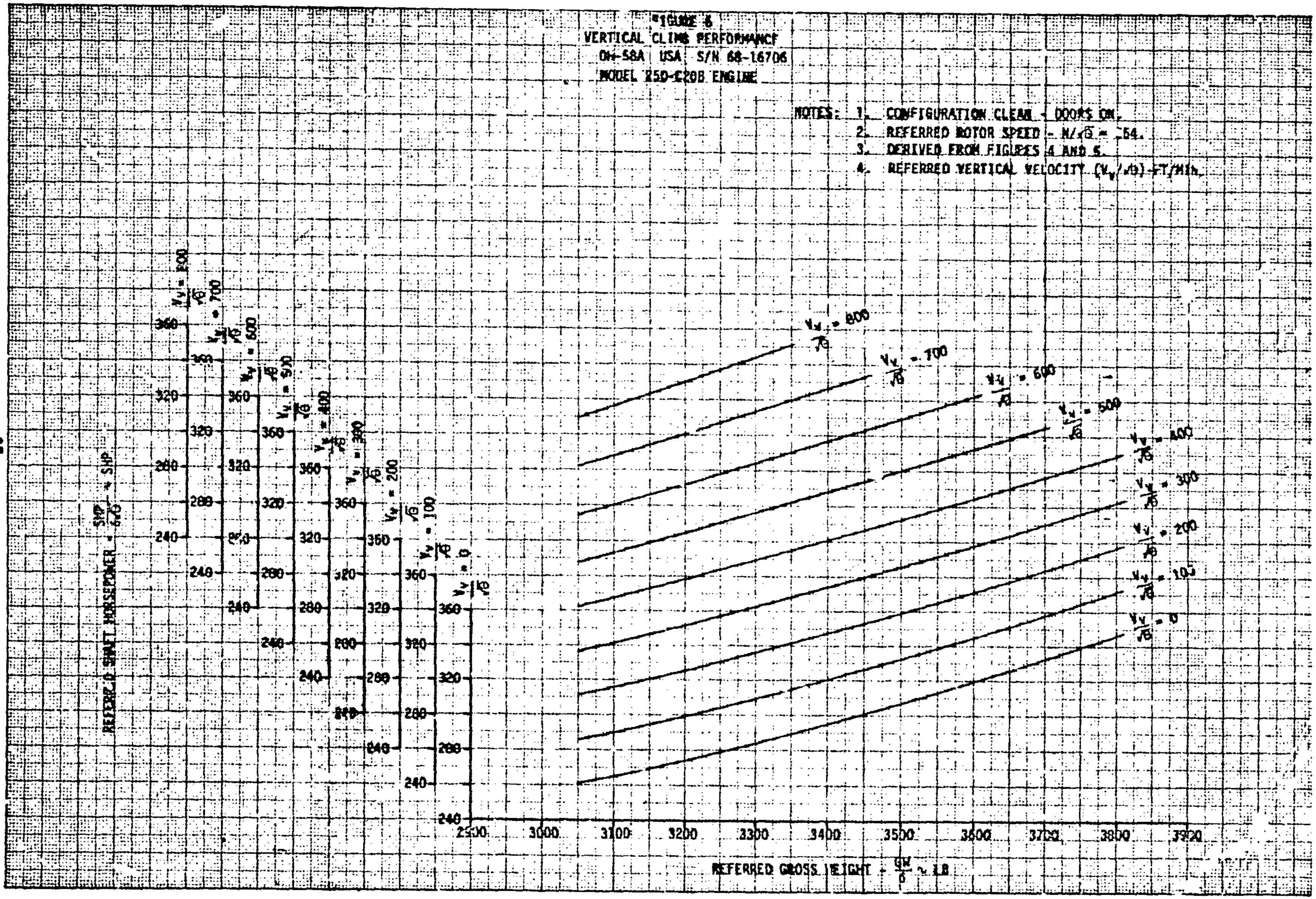


FIGURE 7
NONDIMENSIONAL VERTICAL CLIMB PERFORMANCE
OH-58A USA S/N 68-16706
MODEL 250-C20B ENGINE

SYMBOL	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
○	2780	107.1(FWD)	2360	10.5	351	0.00303
□	2880	107.4(FWD)	2280	9.0	350	0.00315
◇	2980	106.8(FWD)	2330	7.0	349	0.00326
△	3080	107.0(FWD)	1780	5.5	348	0.00336
◁	2890	107.3(FWD)	4520	11.0	351	0.00336

NOTE: CONFIGURATION CLEAN - DOORS ON.

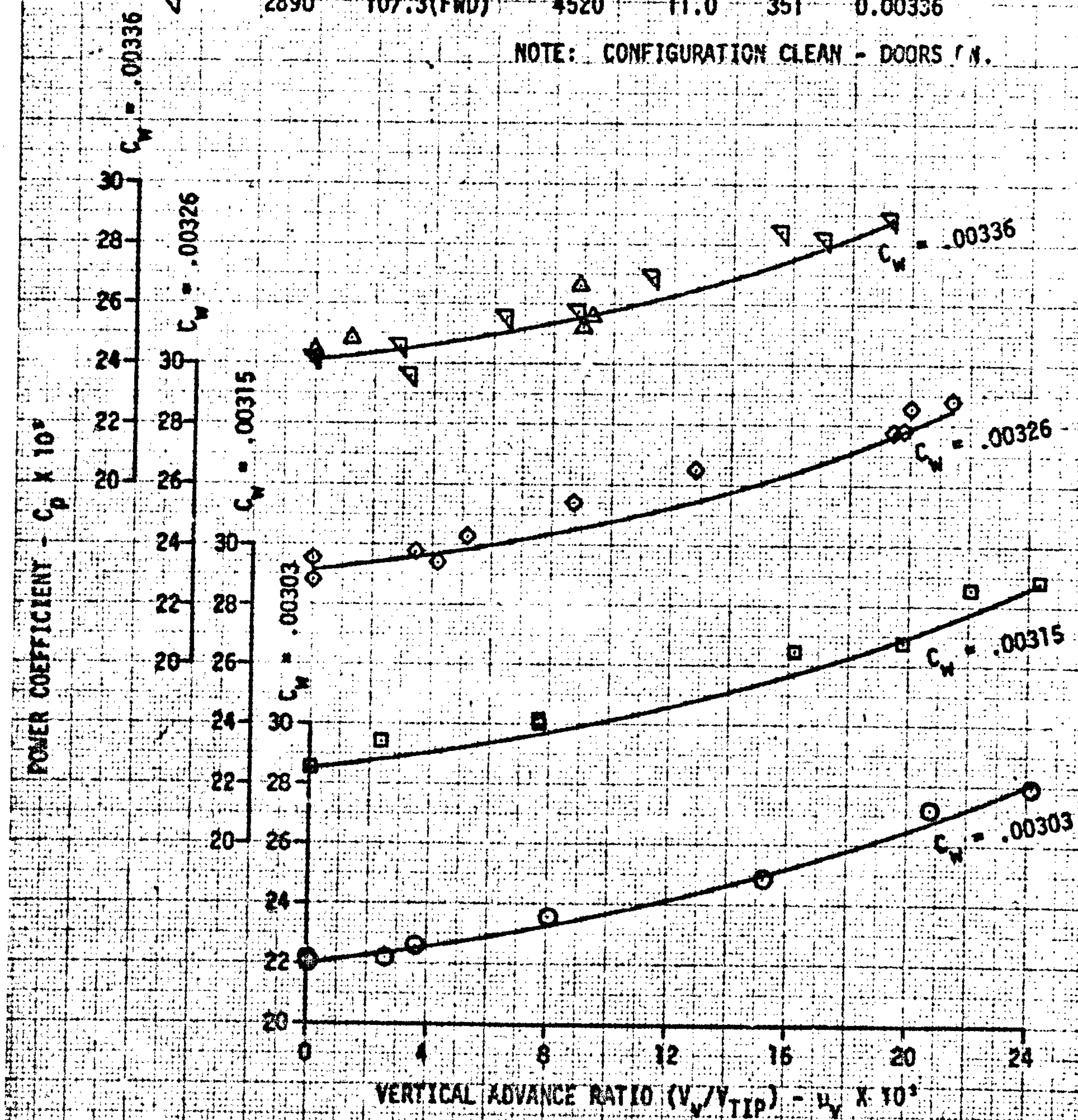


FIGURE 8
NONDIMENSIONAL VERTICAL CLIMB PERFORMANCE
UH-58A USA S/N 68-16706
MODEL 250-C20B ENGINE

SYMBOL	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	AVG ROTOR SPEED ~RPM	AVG C_T
▽	3180	107.2(FWD)	1760	6.0	348	0.00347
△	2950	107.3(FWD)	4860	11.0	351	0.00347
⬡	3090	107.1(FWD)	4120	5.5	348	0.00361
▭	3180	107.7(FWD)	4460	8.5	350	0.00371
⬯	3240	108.0(FWD)	4340	8.0	350	0.00377

NOTE: CONFIGURATION CLEAN - DOORS ON.

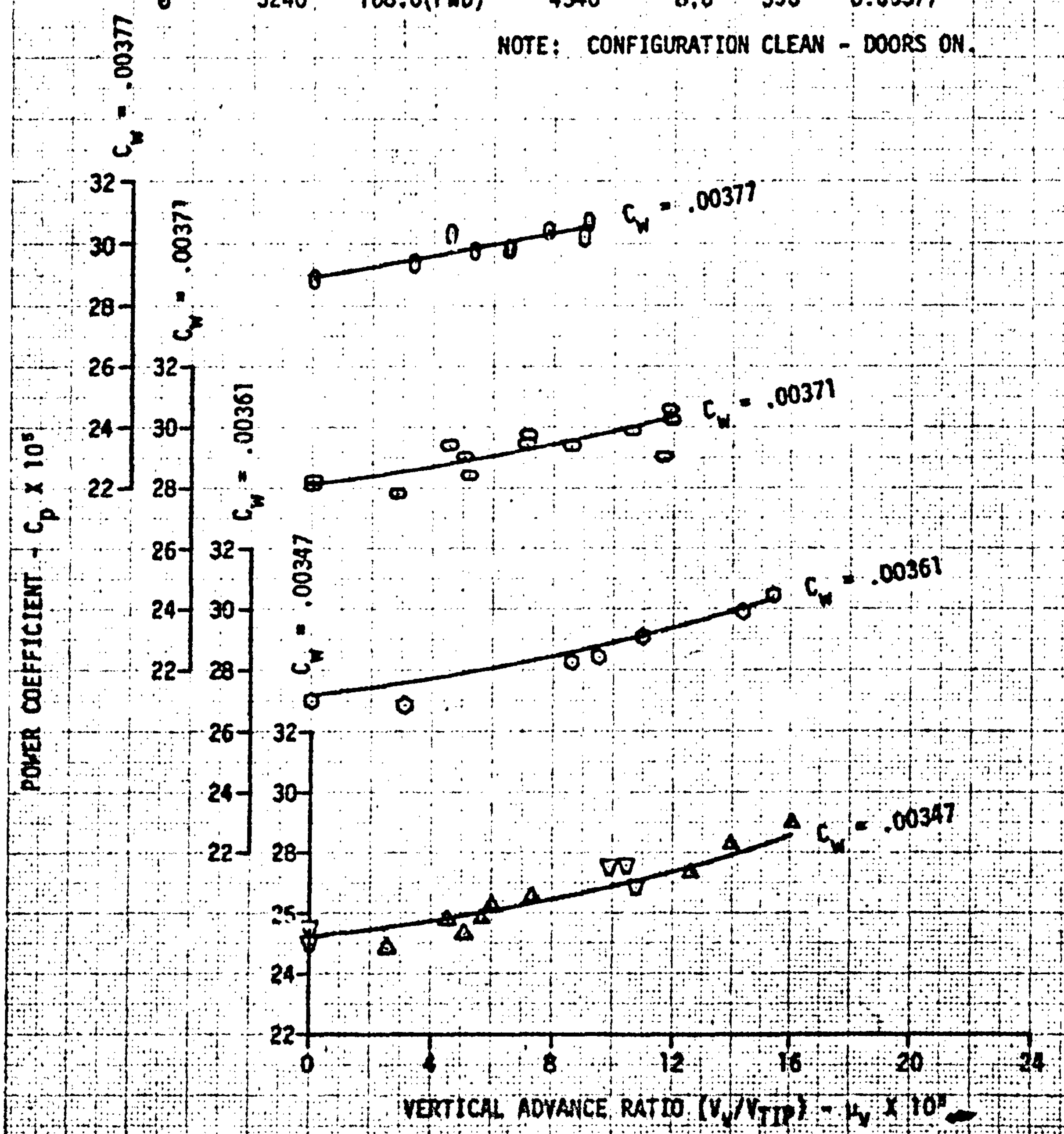


FIGURE 9
NONDIMENSIONAL VERTICAL CLIMB PERFORMANCE
OH-58A USA S/N 68-16706
MODEL 250-C20B ENGINE

NOTES: 1. CONFIGURATION CLEAN - DOORS ON.
2. DERIVED FROM FIGURES 7 AND 8.

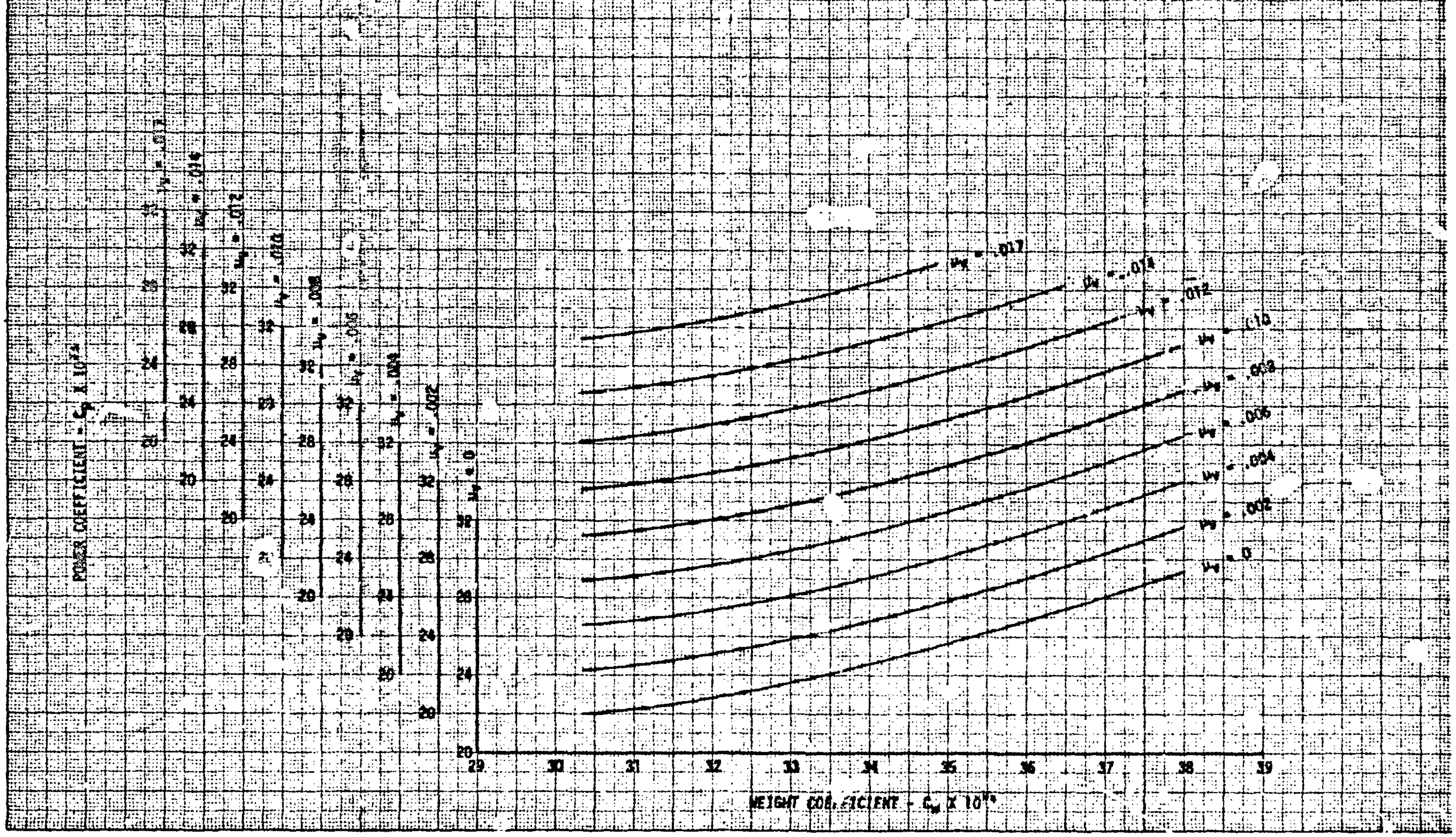


FIGURE 10

LATERAL ACCELERATION

OH-58A USA S/N 68-16706

MODEL 250-C20B ENGINE

SYM	AVG GROSS WEIGHT ~ LB	AVG CG LOCATION ~ IN	AVG DENSITY ALTITUDE ~ FT	AVG OAT ~ DEG C	AVG ROTOR SPEED ~ RPM	AVG C_T
⊙	3180.	107.8	880.	2.0	354	0.00330

NOTES: 1. CONFIGURATION CLEAN-DOORS ON
2. SCAS ON

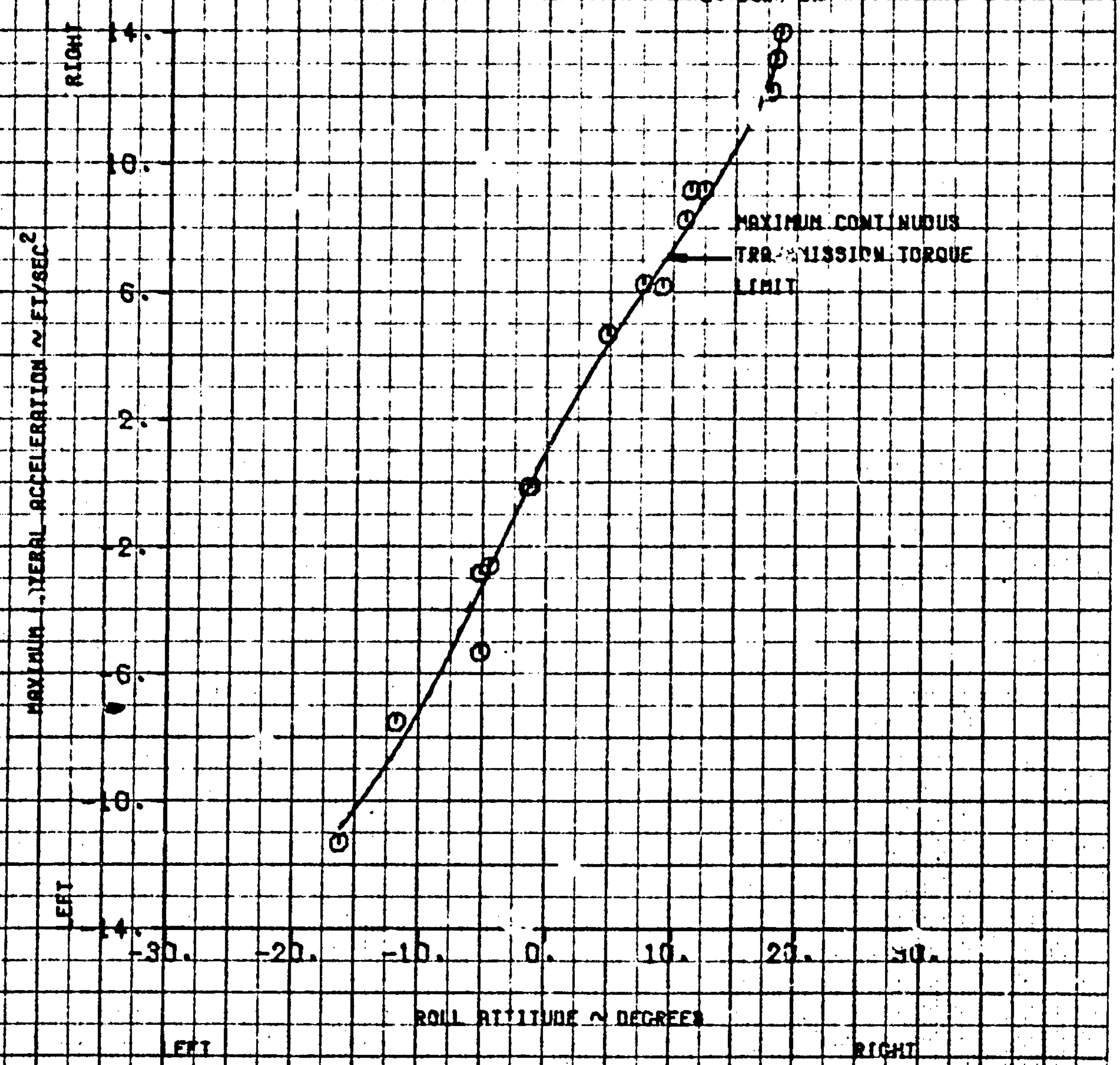


FIGURE 11

LEFT LATERAL ACCELERATION

JOH-58A S/N 68-16706
MODEL 250-C20B ENGINE

GROSS WEIGHT — LB	CG LOCATION — IN	DENSITY ALTITUDE — FT	OAT — DEG C	ROTOR SPEED — RPM	AIRSPEED — KCAS	THRUST COEFFICIENT	CONFIGURATION	SCAS MODE
3180	107.7 (FWD)	640	0.0	354	ZERO	0.003239	CLEAN-DOORS ON	ON

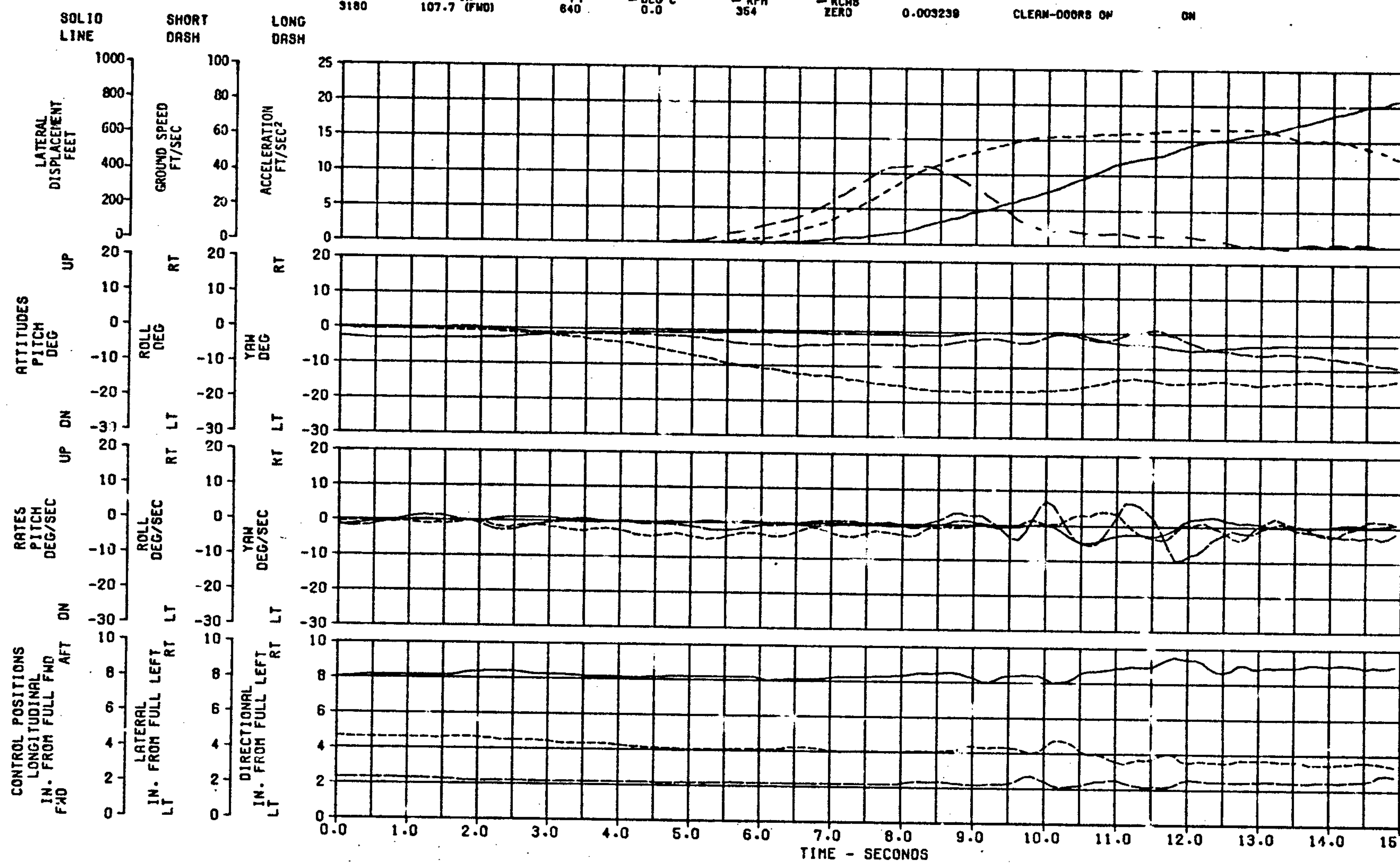


FIGURE 11A

LEFT LATERAL ACCELERATION

JOH-58A S/N 68-16706

MODEL 250-C20B ENGINE

GROSS WEIGHT - LB	CG LOCATION - IN	DENSITY ALTITUDE - FT	OAT - DEG C	ROTOR SPEED - RPM	AIRSPEED - KCAS	THRUST COEFFICIENT	CONFIGURATION	SCAS MODE
3180	107.7 (FWD)	640	0.0	354	ZERO	0.003239	CLEAN-DOORS ON	ON

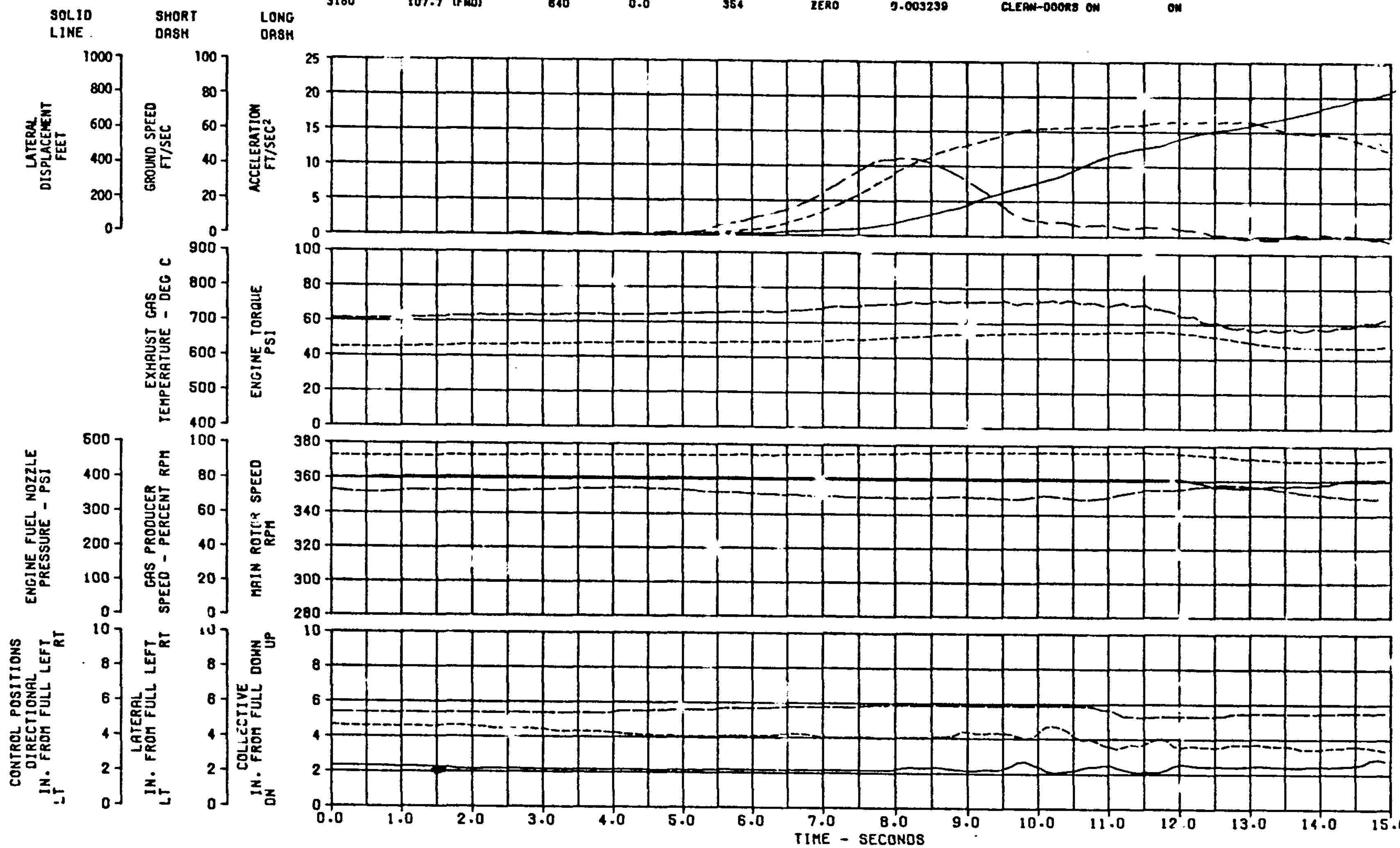


FIGURE 12
RIGHT LATERAL ACCELERATION
JOH-58A S/N 68-16706
MODEL 250-C20B ENGINE

GROSS WEIGHT - LB	CG LOCATION - IN	DENSITY ALTITUDE - FT	OAT - DEG C	ROTOR SPEED - RPM	AIRSPEED - KCAS	THRUST COEFFICIENT	CONFIGURATION	SCAS MODE
3180	107 (FWD)	660	0.0	354	ZERO	0.003243	CLEAN-DOORS ON	ON

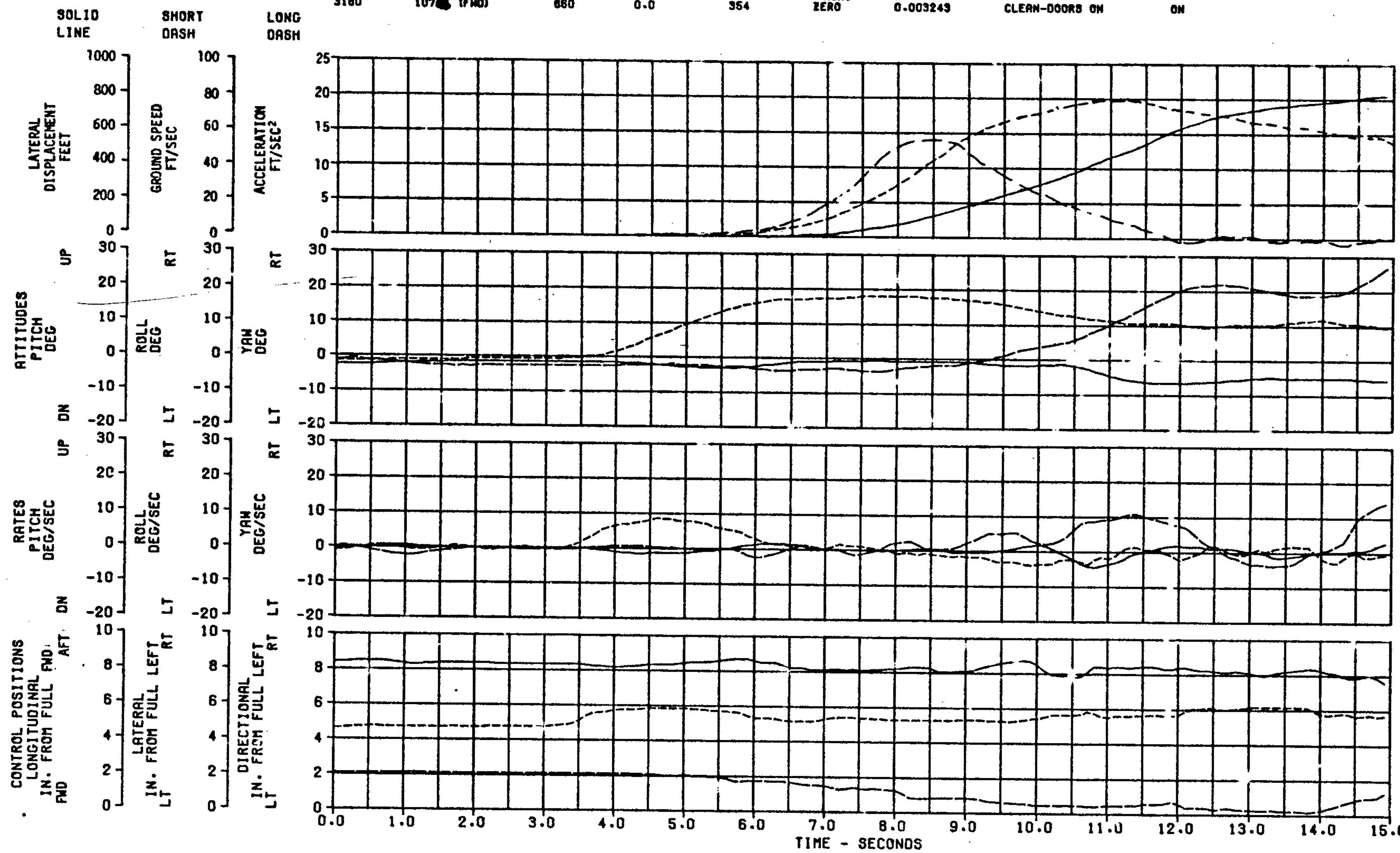


FIGURE 12A
RIGHT LATERAL ACCELERATION
JOH-58A S/N 68-1670
MODEL 250-C20B ENGINE

GROSS WEIGHT LB	CG LOCATION IN	DENSITY ALTITUDE FT	OAT DEG C	ROTOR SPEED RPM	AIRSPEED KCAS	THRUST COEFFICIENT	CONFIGURATION	SCAS MODE
3180	107.7 (FWD)	860	0.0	354	ZERO	0.003243	CLEAN-DOORS ON	ON

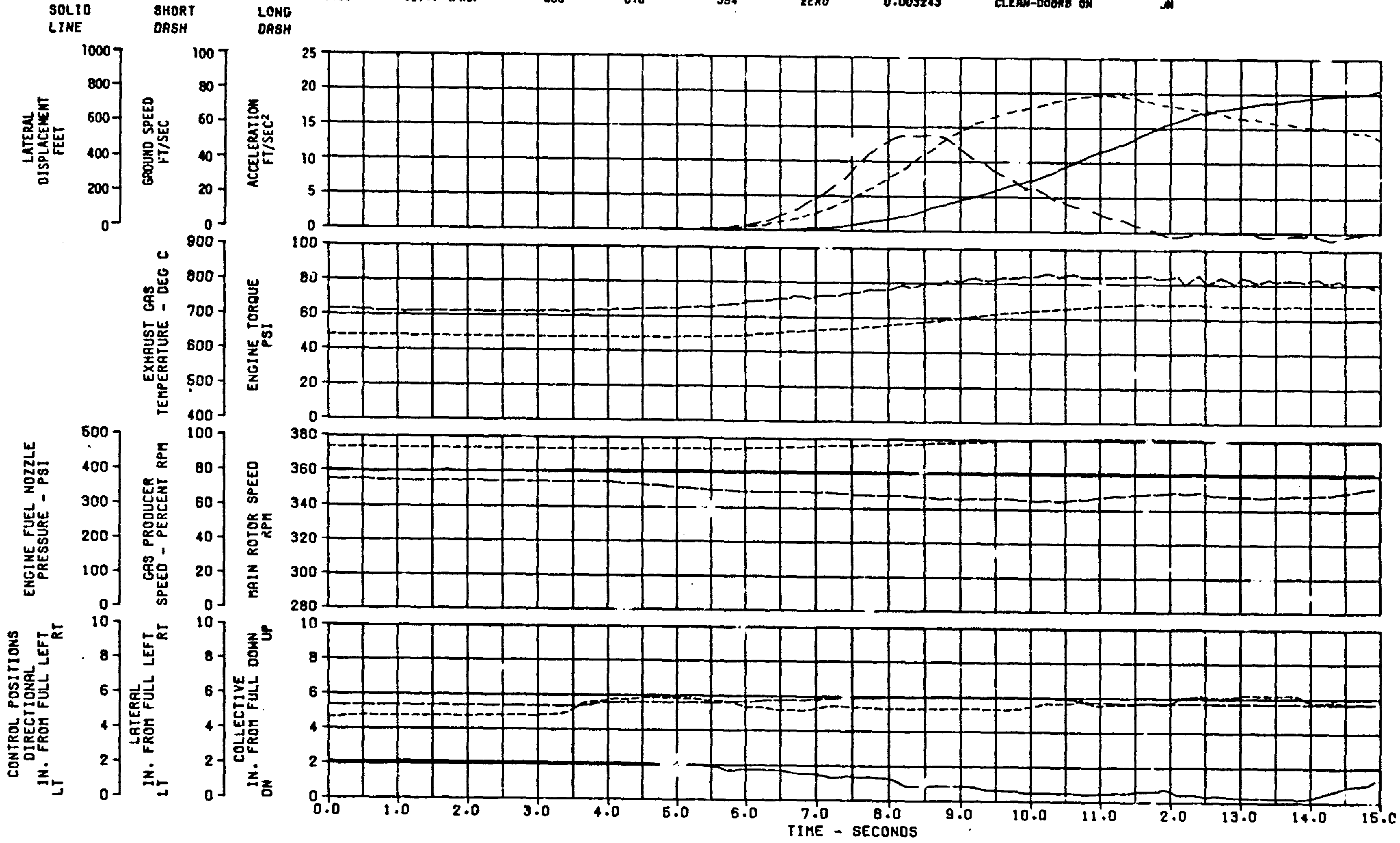
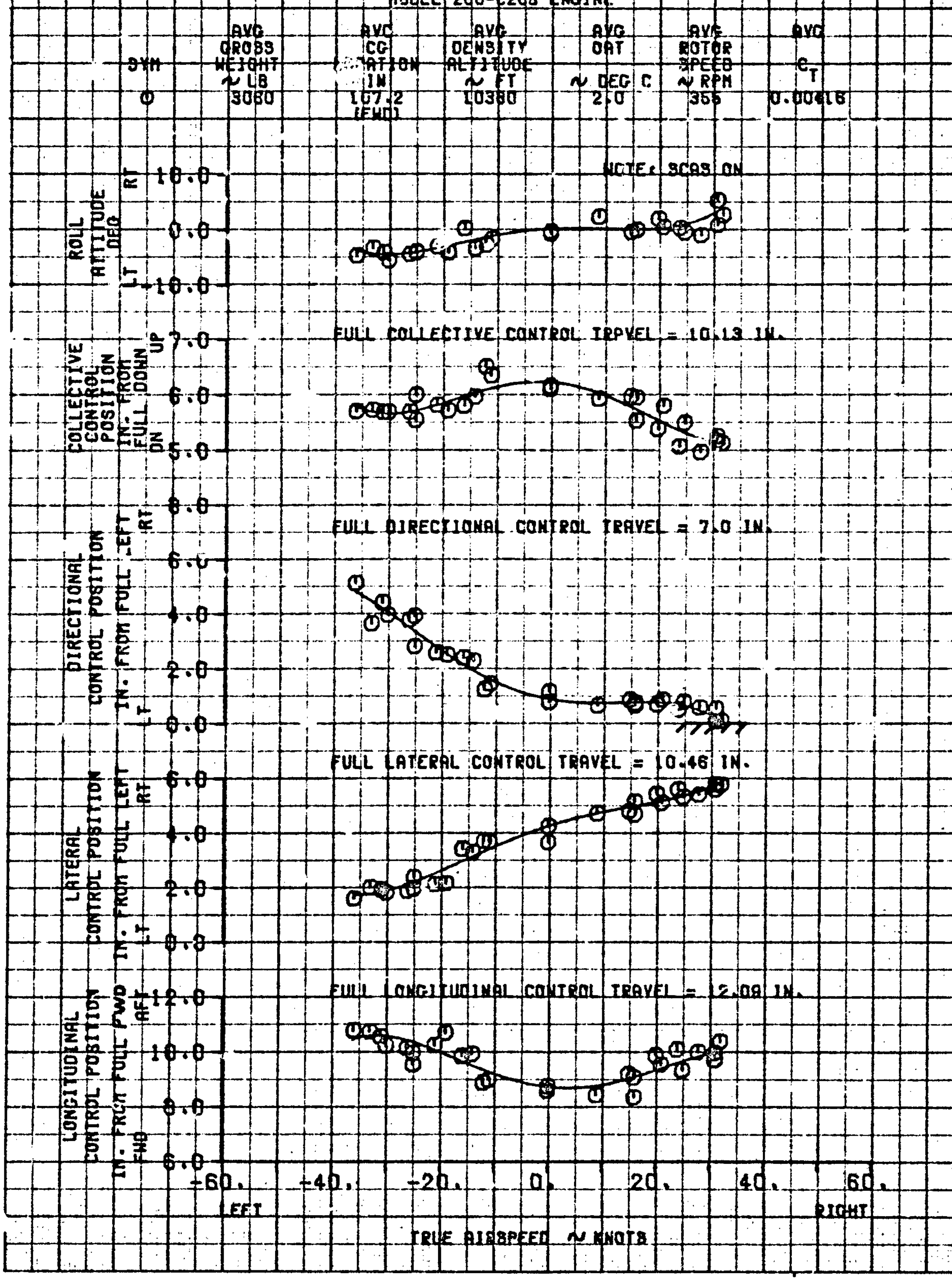


FIGURE 13
CONTROL POSITIONS IN SIDEWARD FLIGHT
OH-58A USA S/N 68-16708
MODEL 250-C20B ENGINE



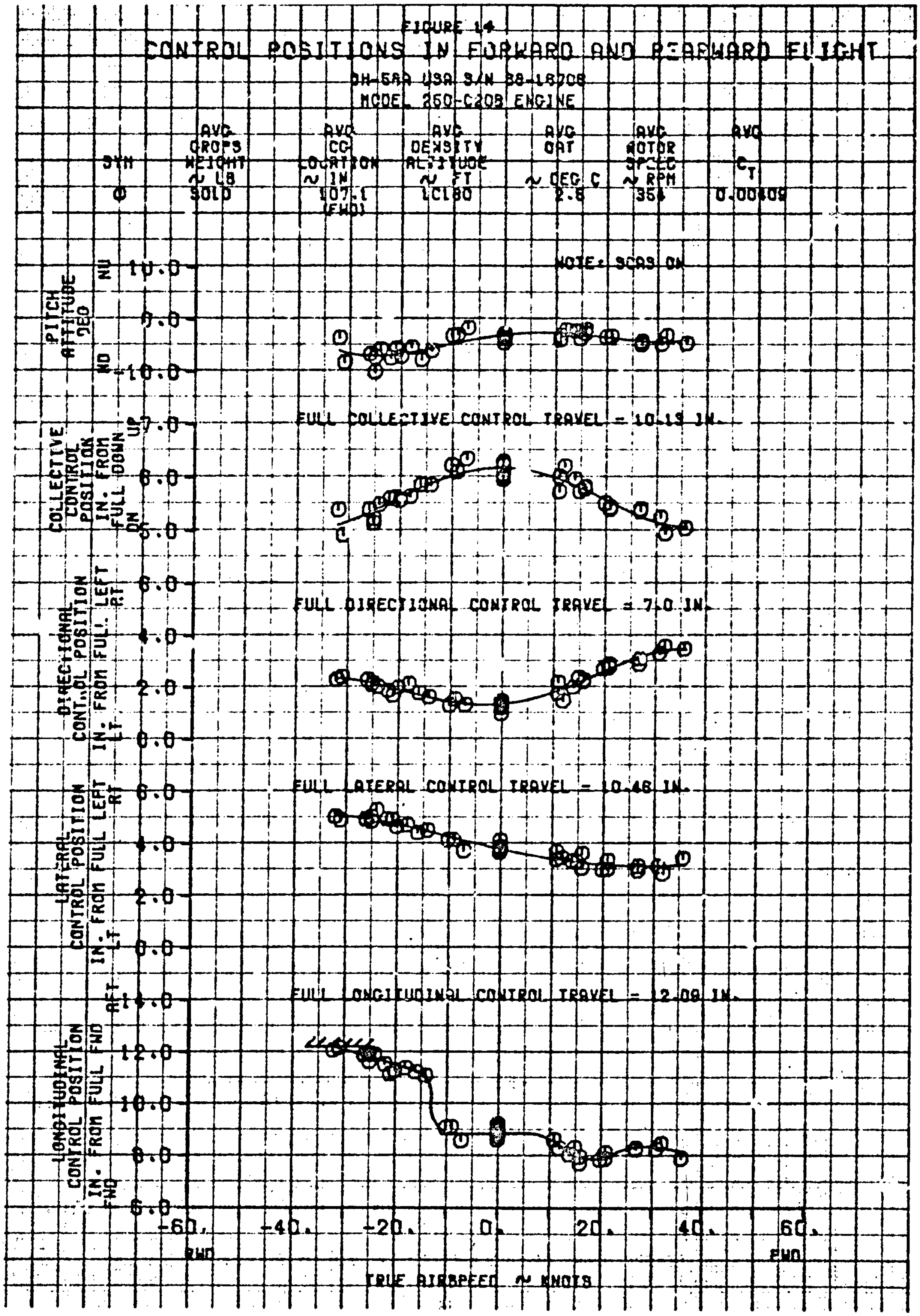


FIGURE 14
CONTROL POSITIONS IN FORWARD AND REARWARD FLIGHT
OH-58A USA S/N 68-16708
MODEL 250-C20B ENGINE
SYM
AVG GROSS WEIGHT ~ LB
AVG CG LOCATION ~ IN
AVG DENSITY ALTITUDE ~ FT
AVG OAT ~ DEG C
AVG ROTOR SPEED ~ RPM
AVG C_T
3010
107.1 (FWD)
1C180
2.8
354
0.00409
NOTE: SCAS ON
PITCH ATTITUDE DEG
NU
ND
FULL COLLECTIVE CONTROL TRAVEL = 10.13 IN.
COLLECTIVE CONTROL POSITION IN. FROM FULL DOWN
UP
DN
FULL DIRECTIONAL CONTROL TRAVEL = 7.0 IN.
DIRECTIONAL CONTROL POSITION IN. FROM FULL LEFT
RT
LT
FULL LATERAL CONTROL TRAVEL = 10.46 IN.
LATERAL CONTROL POSITION IN. FROM FULL LEFT
RT
LT
FULL LONGITUDINAL CONTROL TRAVEL = 12.08 IN.
LONGITUDINAL CONTROL POSITION IN. FROM FULL FWD
AFT
FWD
-60. -40. -20. 0. 20. 40. 60.
RWD
FWD
TRUE AIRSPEED ~ KNOTS

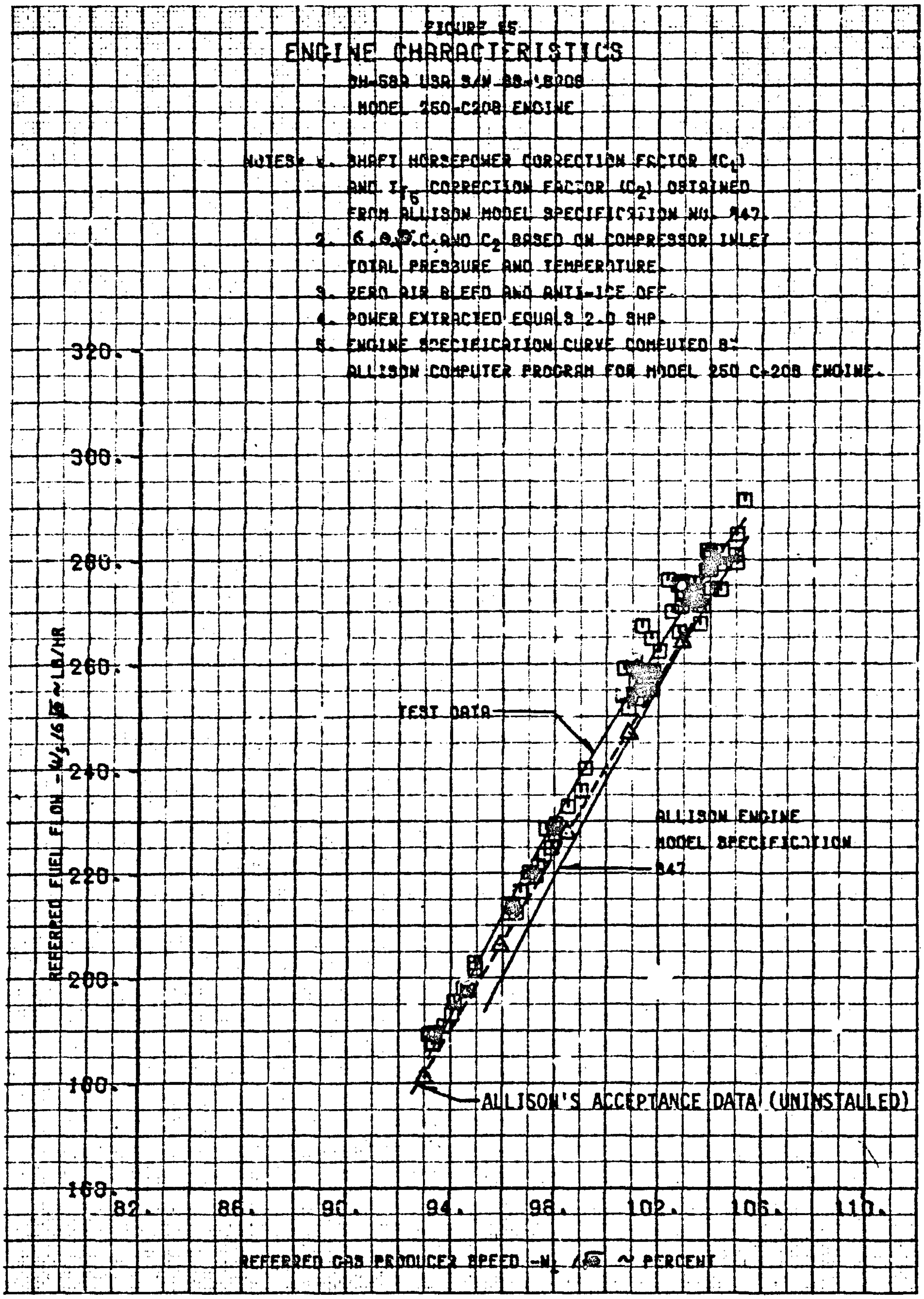


FIGURE 55
ENGINE CHARACTERISTICS
MODEL 250-C20B ENGINE
NOTES: 1. SHAFT HORSEPOWER CORRECTION FACTOR (C1)
AND T5 CORRECTION FACTOR (C2) OBTAINED
FROM ALLISON MODEL SPECIFICATION NO. 947.
2. C1 AND C2 BASED ON COMPRESSOR INLET
TOTAL PRESSURE AND TEMPERATURE.
3. ZERO AIR BLEED AND ANTI-ICE OFF.
4. POWER EXTRACTED EQUALS 2.0 SHP.
5. ENGINE SPECIFICATION CURVE COMPUTED BY
ALLISON COMPUTER PROGRAM FOR MODEL 250 C-20B ENGINE.
320.
300.
280.
260.
240.
220.
200.
180.
160.
82.
86.
90.
94.
98.
102.
106.
110.
TEST DATA
ALLISON ENGINE
MODEL SPECIFICATION
947
ALLISON'S ACCEPTANCE DATA (UNINSTALLED)
REFERRED FUEL FLOW ~ LB/HR
REFERRED GAS PRODUCER SPEED ~ PERCENT

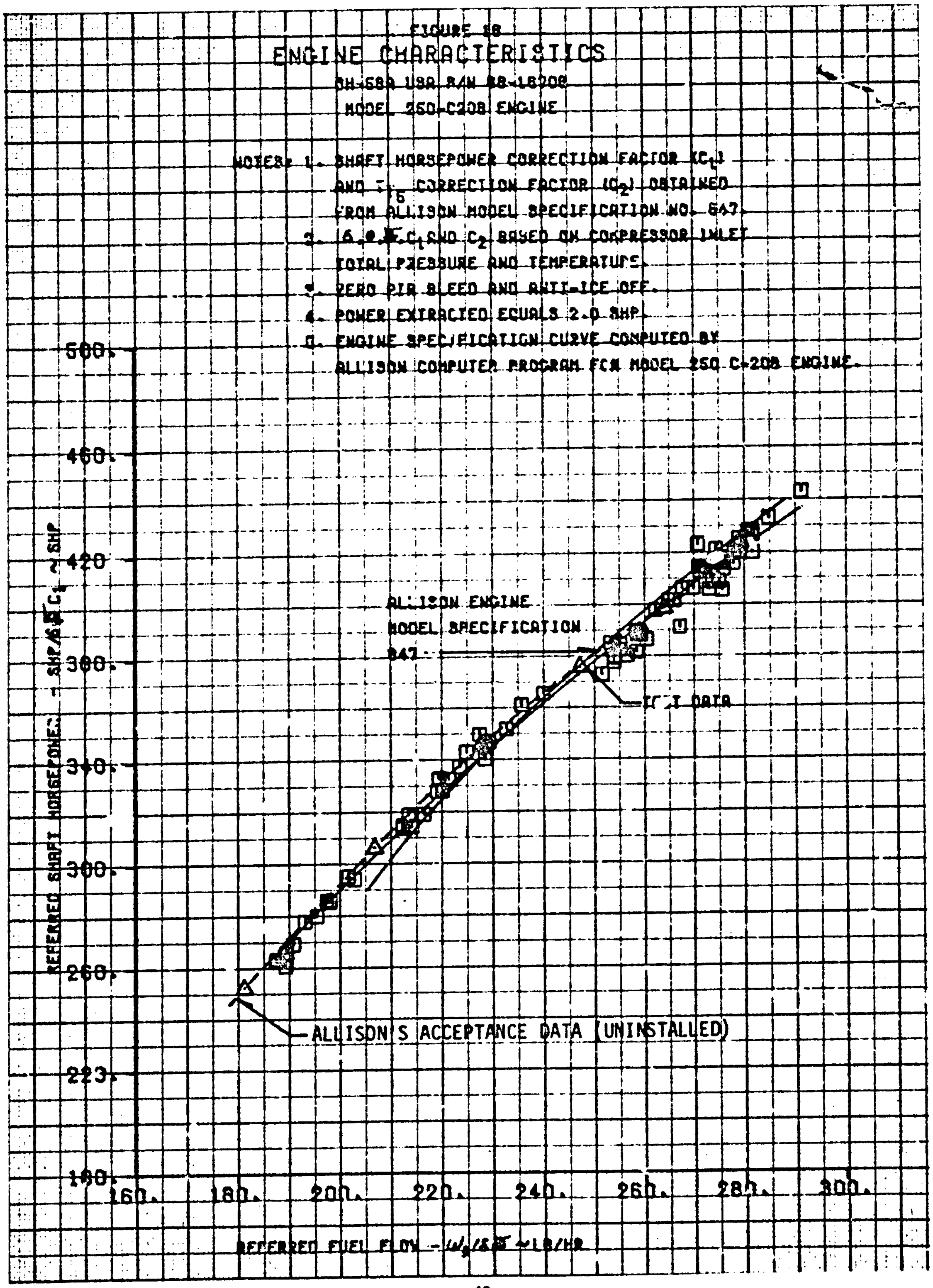


FIGURE 18
ENGINE CHARACTERISTICS
MODEL 250-C20B ENGINE
NOTES: 1. SHAFT HORSEPOWER CORRECTION FACTOR
CORRECTION FACTOR OBTAINED
FROM ALLISON MODEL SPECIFICATION NO. 647.
BASED ON COMPRESSOR INLET
TOTAL PRESSURE AND TEMPERATURE.
ZERO AIR BLEED AND ANTI-ICE OFF.
POWER EXTRACTED EQUALS 2.0 SHP.
ENGINE SPECIFICATION CURVE COMPUTED BY
ALLISON COMPUTER PROGRAM FOR MODEL 250 C-20B ENGINE.
ALLISON ENGINE
MODEL SPECIFICATION
647
ALLISON'S ACCEPTANCE DATA (UNINSTALLED)
REFERRED SHAFT HORSEPOWER
500.
460.
420.
380.
340.
300.
260.
220.
180.
160.
200.
240.
280.
REFERRED FUEL FLOW

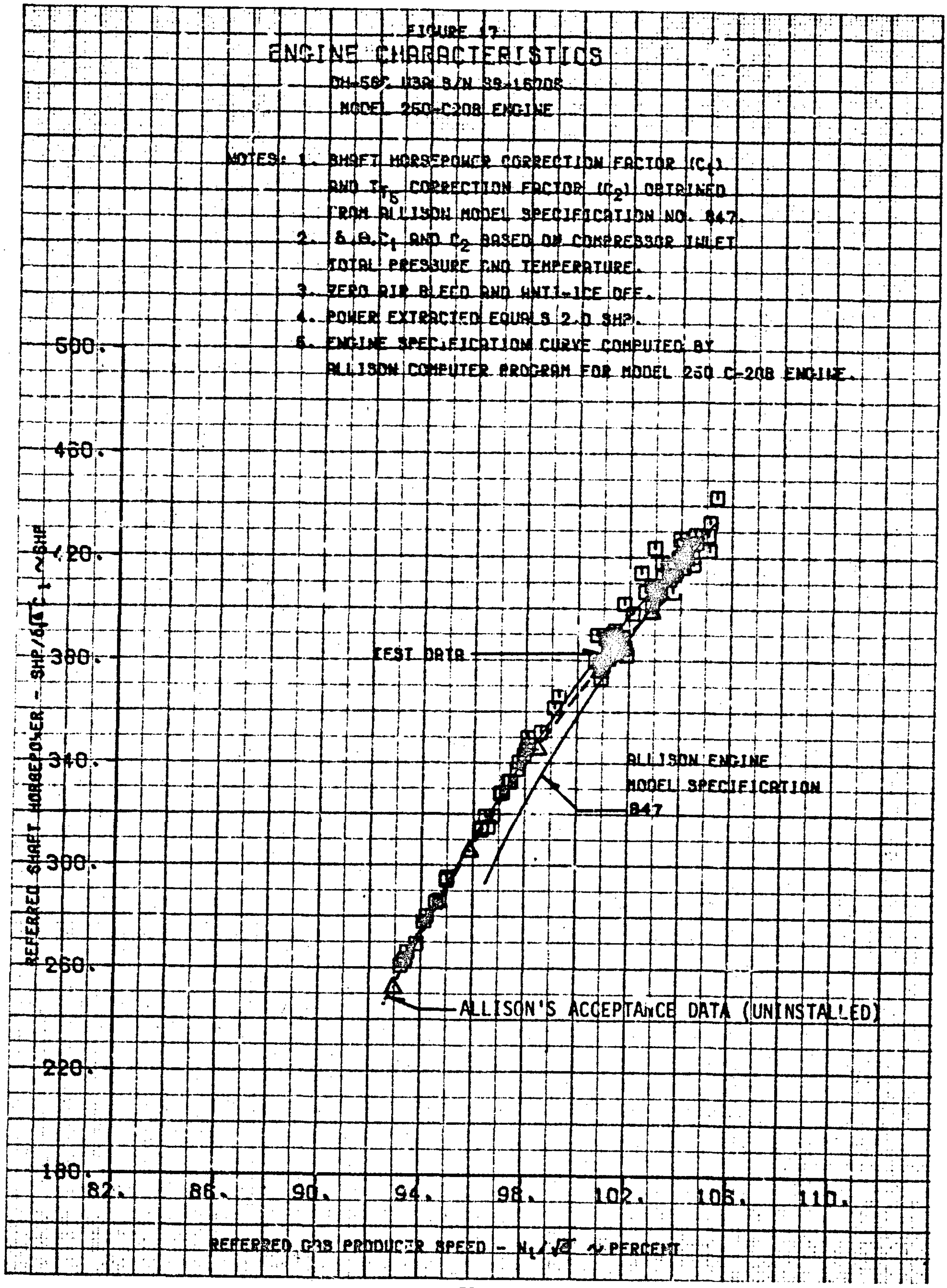


FIGURE 17
ENGINE CHARACTERISTICS
MODEL 250-C20B ENGINE
NOTES: 1. SHAFT HORSEPOWER CORRECTION FACTOR (C_1) AND T_{t5} CORRECTION FACTOR (C_2) OBTAINED FROM ALLISON MODEL SPECIFICATION NO. 847.
2. δ, θ, C_1 AND C_2 BASED ON COMPRESSOR INLET TOTAL PRESSURE AND TEMPERATURE.
3. ZERO AIR BLEED AND ANTI-ICE OFF.
4. POWER EXTRACTED EQUALS 2.0 SHP.
5. ENGINE SPECIFICATION CURVE COMPUTED BY ALLISON COMPUTER PROGRAM FOR MODEL 250 C-20B ENGINE.
TEST DATA
ALLISON ENGINE MODEL SPECIFICATION 847
ALLISON'S ACCEPTANCE DATA (UNINSTALLED)
REFERRED SHAFT HORSEPOWER - SHP/$\delta\sqrt{\theta}$ C_1 ~ SHP
500.
460.
420.
380.
340.
300.
260.
220.
180.
82.
86.
90.
94.
98.
102.
106.
110.
REFERRED GAS PRODUCER SPEED - $N_1/\sqrt{\theta}$ ~ PERCENT

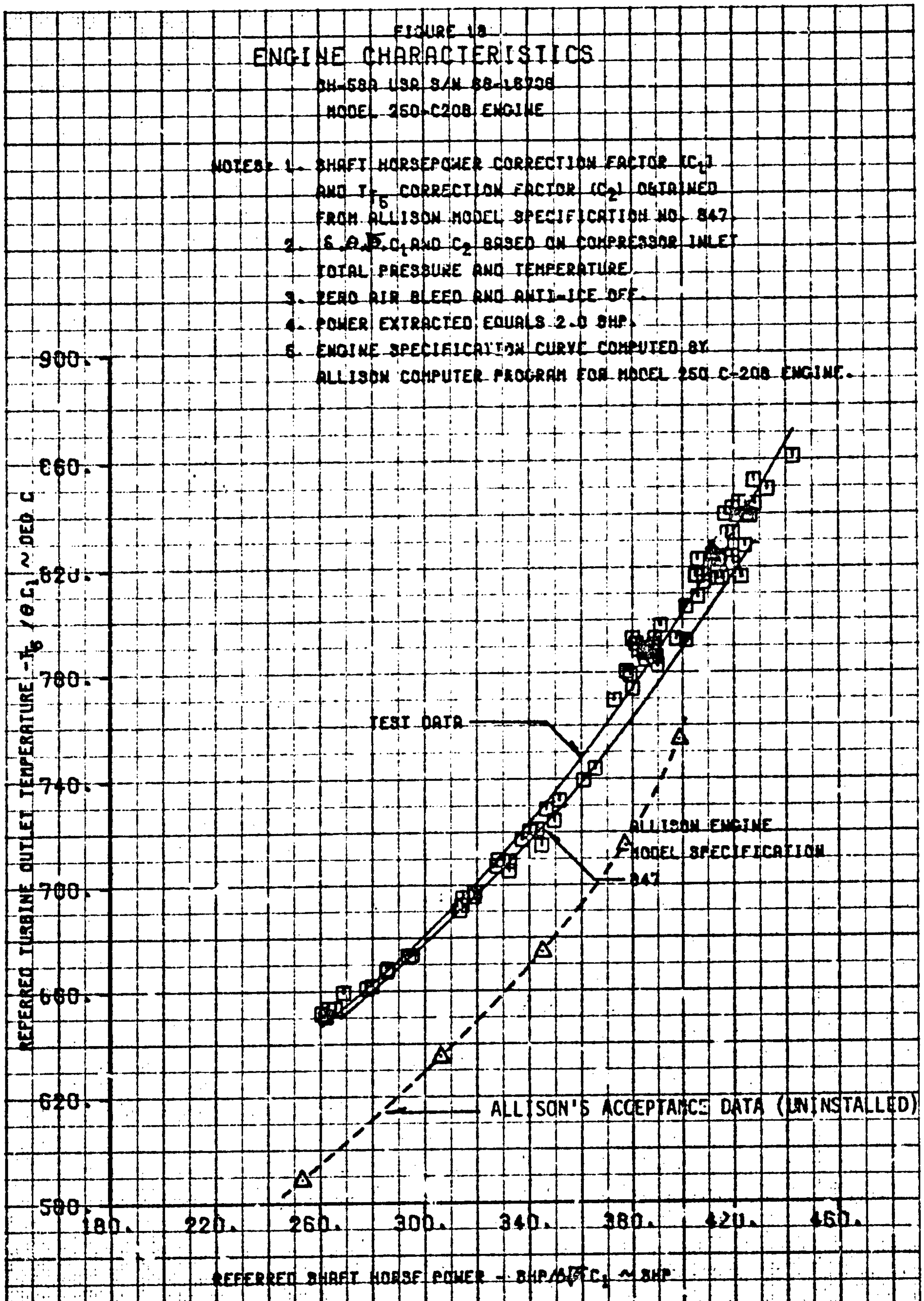
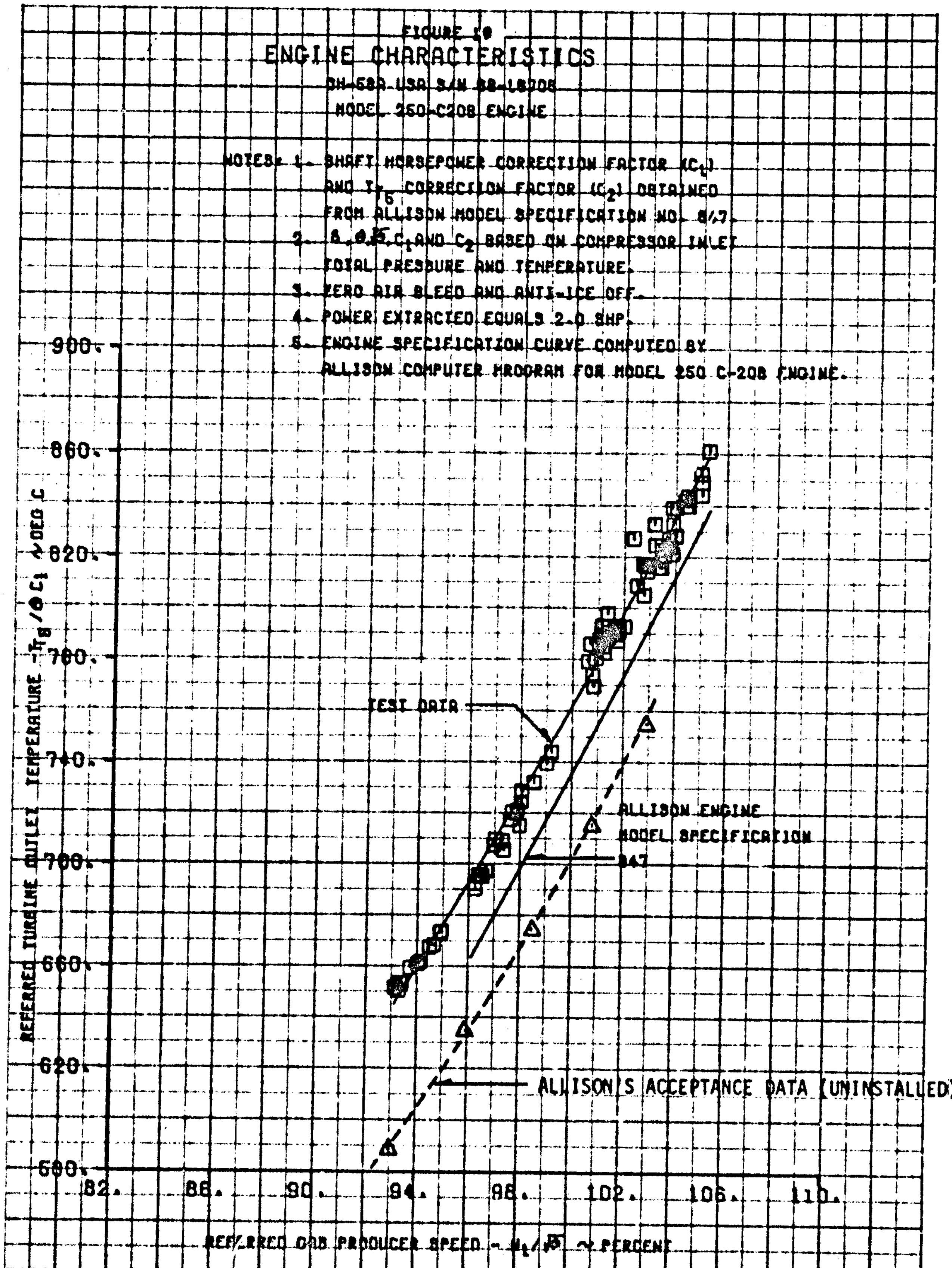


FIGURE 18
ENGINE CHARACTERISTICS
OH-58A USA S/N 68-16738
MODEL 250-C20B ENGINE
NOTES: 1. SHAFT HORSEPOWER CORRECTION FACTOR (C_1) AND T_{t5} CORRECTION FACTOR (C_2) OBTAINED FROM ALLISON MODEL SPECIFICATION NO. 847.
2. $\delta, \theta, \sqrt{\theta}$, C_1 AND C_2 BASED ON COMPRESSOR INLET TOTAL PRESSURE AND TEMPERATURE.
3. ZERO AIR BLEED AND ANTI-ICE OFF.
4. POWER EXTRACTED EQUALS 2.0 SHP.
5. ENGINE SPECIFICATION CURVE COMPUTED BY ALLISON COMPUTER PROGRAM FOR MODEL 250 C-20B ENGINE.
TEST DATA
ALLISON ENGINE MODEL SPECIFICATION 847
ALLISON'S ACCEPTANCE DATA (UNINSTALLED)
REFERRED TURBINE OUTLET TEMPERATURE - $T_{t5}/\theta C_2$ ~ DEG C
REFERRED SHAFT HORSE POWER - $SHP/\delta\sqrt{\theta}C_1$ ~ SHP
900.
860.
820.
780.
740.
700.
660.
620.
580.
180.
220.
260.
300.
340.
380.
420.
460.


ENGINE CHARACTERISTICS
MODEL 250-C20B ENGINE
NOTES: 1. SHAFT HORSEPOWER CORRECTION FACTOR (C_1) AND T_5 CORRECTION FACTOR (C_2) OBTAINED FROM ALLISON MODEL SPECIFICATION NO. 847.
2. δ, θ, $\sqrt{\theta}$, C_1 AND C_2 BASED ON COMPRESSOR INLET TOTAL PRESSURE AND TEMPERATURE.
3. ZERO AIR BLEED AND ANTI-ICE OFF.
4. POWER EXTRACTED EQUALS 2.0 SHP.
5. ENGINE SPECIFICATION CURVE COMPUTED BY ALLISON COMPUTER PROGRAM FOR MODEL 250 C-20B ENGINE.
900.
860.
820.
780.
740.
700.
660.
620.
600.
82.
86.
90.
94.
98.
102.
106.
110.
TEST DATA
ALLISON ENGINE MODEL SPECIFICATION 847
ALLISON'S ACCEPTANCE DATA (UNINSTALLED)

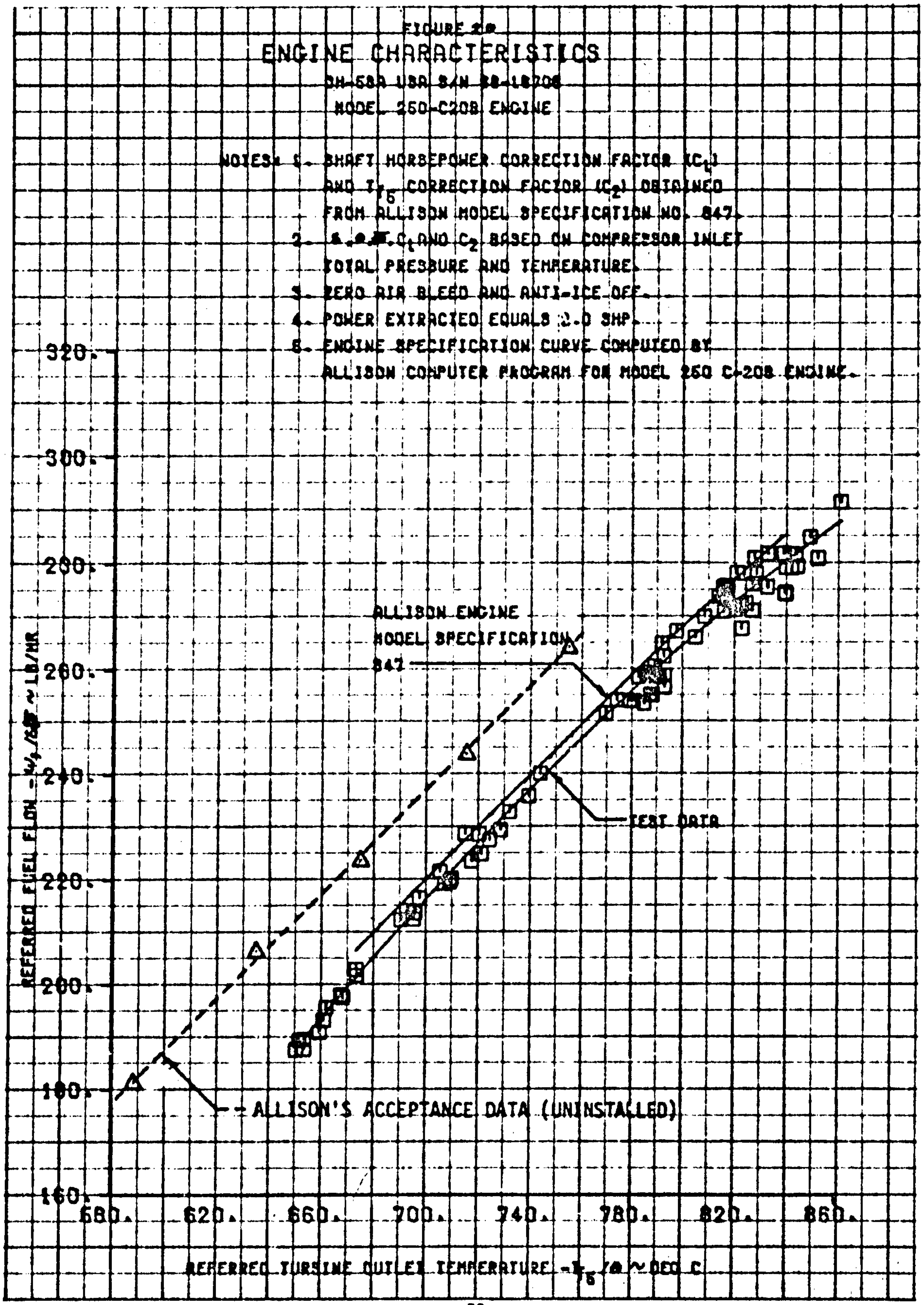

ENGINE CHARACTERISTICS
MODEL 250-C20B ENGINE
SHAFT HORSEPOWER CORRECTION FACTOR
CORRECTION FACTOR
FROM ALLISON MODEL SPECIFICATION NO. 847.
BASED ON COMPRESSOR INLET
TOTAL PRESSURE AND TEMPERATURE.
ZERO AIR BLEED AND ANTI-ICE OFF.
POWER EXTRACTED EQUALS
ENGINE SPECIFICATION CURVE COMPUTED BY
ALLISON COMPUTER PROGRAM FOR MODEL 250 C-20B ENGINE.
ALLISON ENGINE
MODEL SPECIFICATION
847
TEST DATA
ALLISON'S ACCEPTANCE DATA (UNINSTALLED)
320.
300.
280.
260.
240.
220.
200.
180.
160.
580.
620.
660.
700.
740.
780.
820.
860.
REFERRED FUEL FLOW
LB/HR
REFERRED TURBINE OUTLET TEMPERATURE
DEG C

FIGURE 2[illegible]

SHAFT HORSEPOWER AVAILABLE COMPARISON

MODEL 250-C20B AND T63-A-700 ENGINES

NOTES:

1. SOLID LINES DENOTE MODEL 250-C20B ENGINE TAKEOFF RATED POWER, T_{T5} = 810°C.
2. DASHED LINE DENOTE MODEL T63-A-700 ENGINE TAKEOFF RATED POWER, T_{T5} = 749°C.
3. CURVES DERIVED FROM ALLISON ENGINE SPECIFICATIONS, MODEL 250-C20B, 1 MAY 1973 AND MODEL T63-A-700, 19 JULY 1967.
4. ZERO AIRSPEED AND ANTI-ICE OFF.
5. STATIC CONDITIONS.
6. INLET AND EXHAUST PRESSURE LOSSES OBTAINED FROM REFERENCE 1, APPENDIX A.
7. ACCESSORY LOSS OF 2.0 SHP.

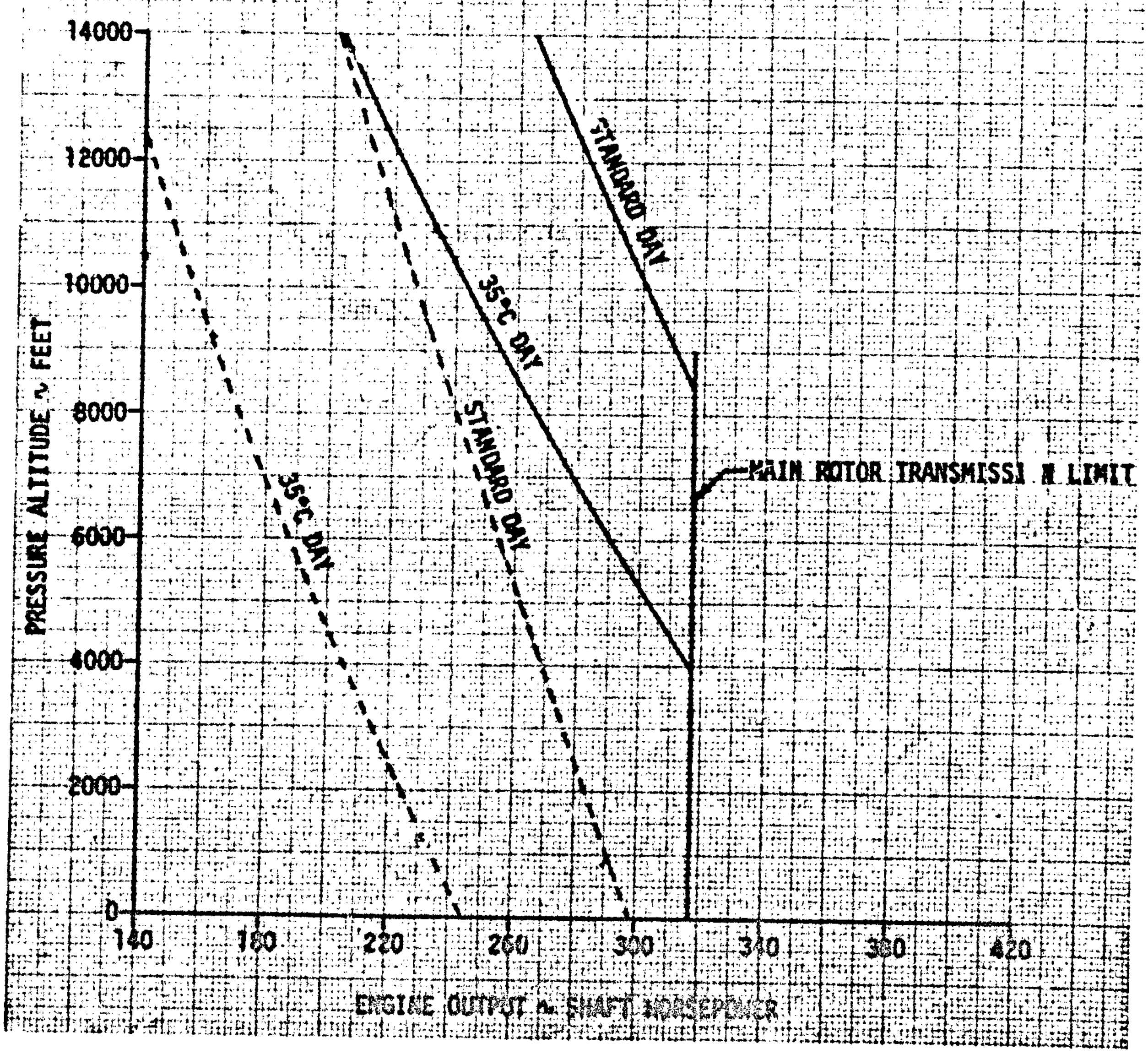


FIGURE 28
SHAFT HORSEPOWER AVAILABLE
ALLISON 250-C20B ENGINE
NORMAL RATED POWER T_{T_5} = 1360°F

NOTES:
1. STATIC CONDITIONS.
2. ZERO BLEED AND ANTI-ICE OFF.
3. POWER EXTRACTED EQUALS 2.0 SHP.
4. INLET AND EXHAUST PRESSURE LOSSES OBTAINED FROM REFERENCE 1, APPENDIX A.
5. SHAFT HORSEPOWER BASED ON ALLISON COMPUTER DECK NO. 847.

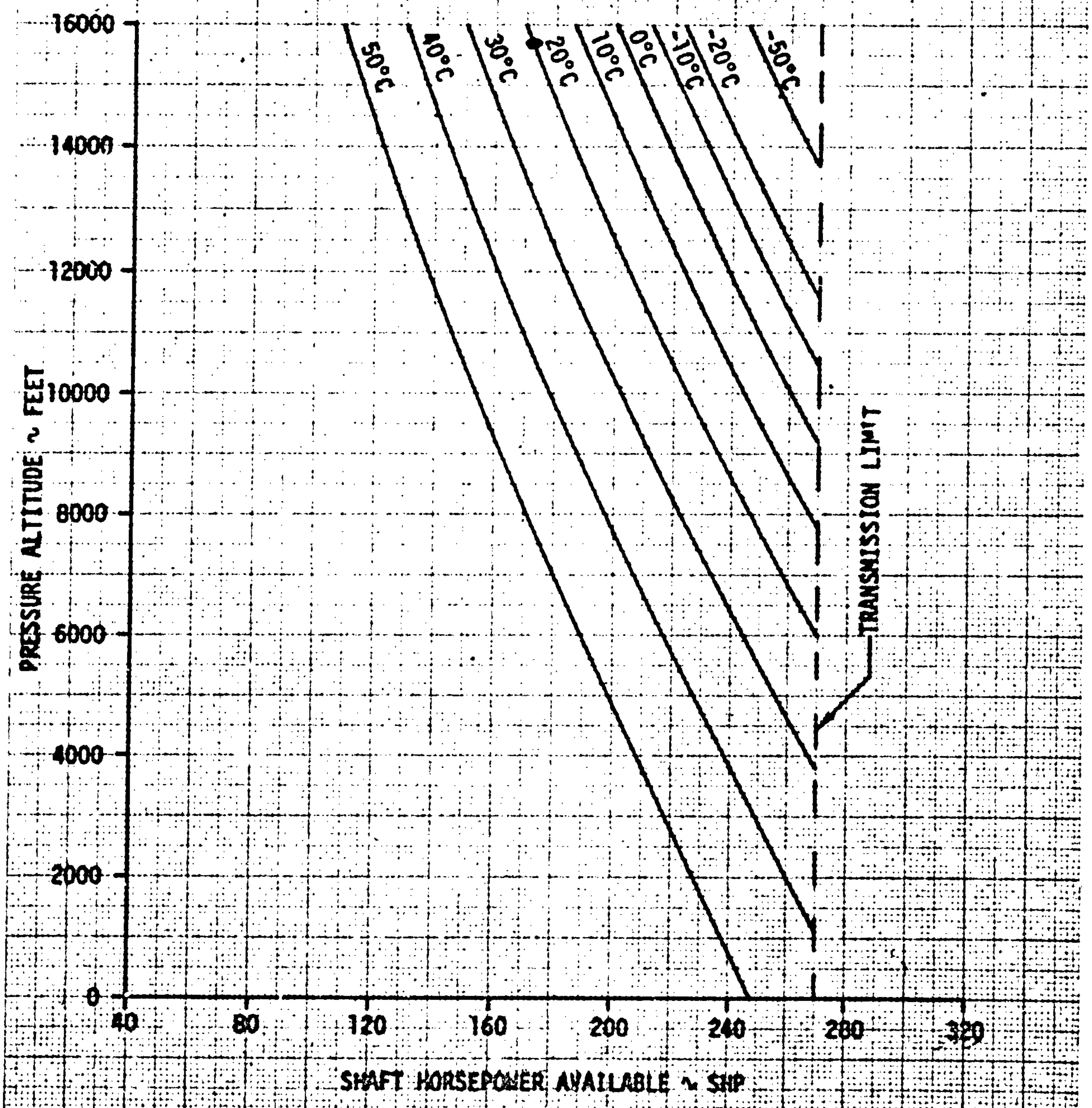


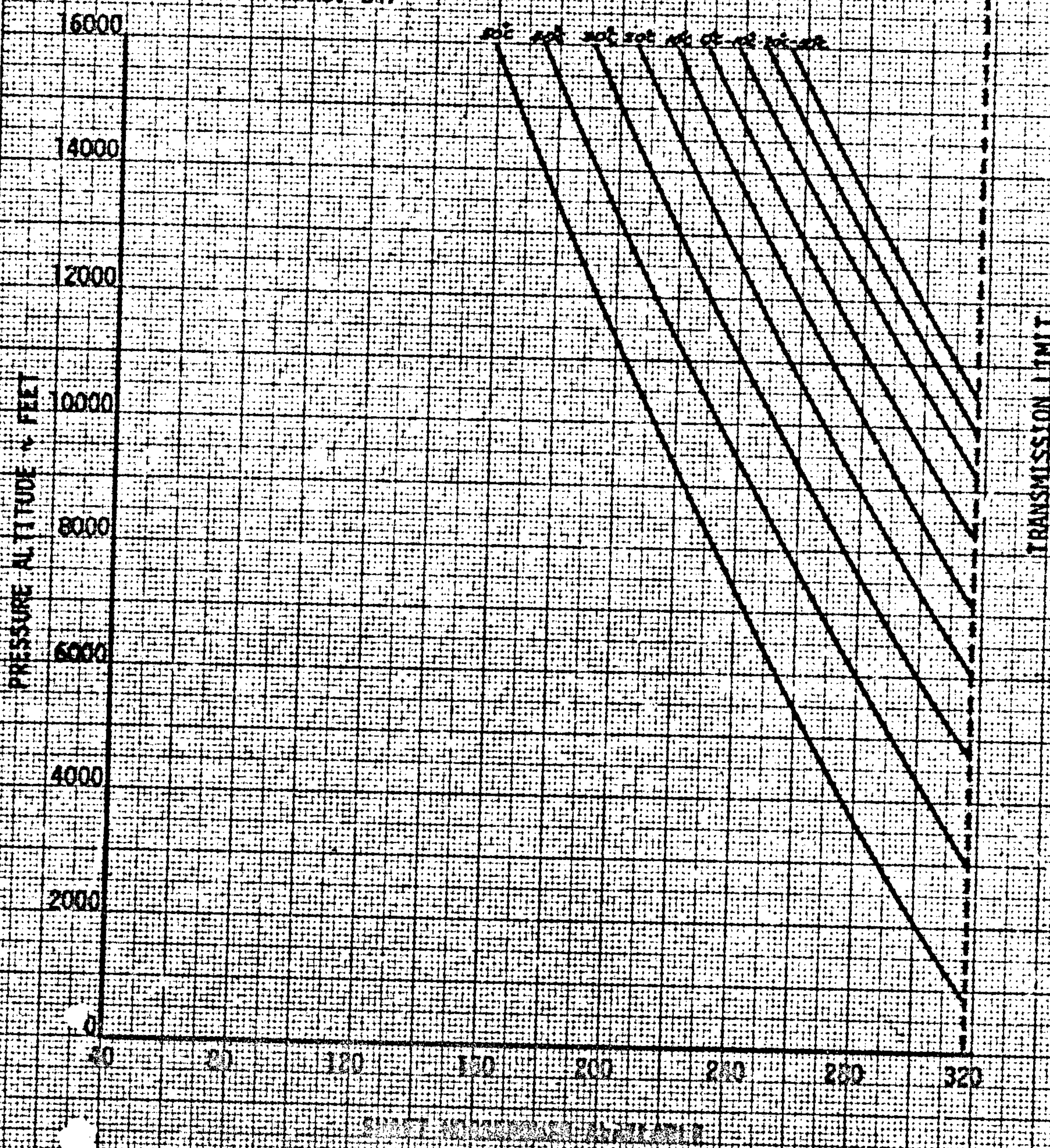
FIGURE 23

SHAFT HORSEPOWER AVAILABLE

ALLISON 250-C20B ENGINE

TAKEOFF RATED POWER T_{T_5} = 1490°F

NOTE:
1. STATIC CONDITIONS
2. ZERO BLEED AND ANTI-ICE OFF
3. POWER EXTRACTED EQUALS 2.0 SHP
4. INLET AND EXHAUST PRESSURE LOSSES OBTAINED FROM REFERENCE 1, APPENDIX A
5. SHAFT HORSEPOWER BASED ON ALLISON COMPUTER DECK NO. 847



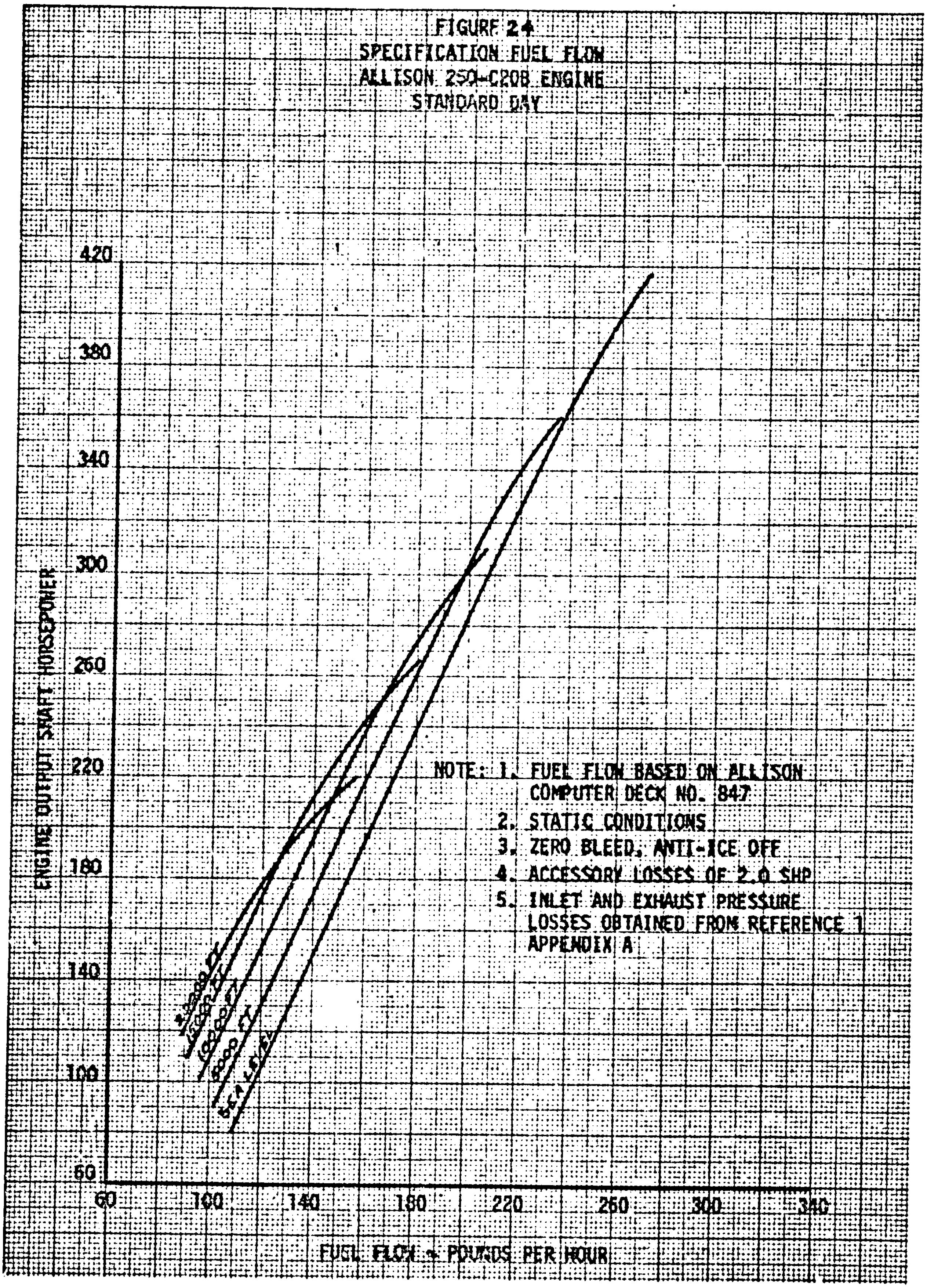


FIGURE 24
SPECIFICATION FUEL FLOW
ALLISON 250-C20B ENGINE
STANDARD DAY

FIGURE 25
ACCESSORY GEARBOX LONGITUDINAL AXIS VIBRATION

FLIGHT CONDITION	SOURCE		MAXIMUM AVERAGE ACCELERATION (g)	FREQUENCY (Hz)
Ground-idle	Tail rotor	8/rev	1.25	350.4
Flight-idle	Note[1]		---	---
Hover (IGE)	Tail rotor	12/rev	2.08	525.6
Normal takeoff	Tail rotor	12/rev	1.95	525.6
Level flight at 80 kt	Tail rotor	12/rev	1.87	525.6
50-kt climb at 500 ft/min	---	---	---	---
80-kt climb at 500 ft/min	---	---	---	---
80-kt climb at maximum power	Tail rotor	12/rev	1.98	525.6
50-kt descent at 500 ft/min	Main rotor	Fundamental	0.52	5.9
	Main rotor	2/rev	0.42	11.8
	Main rotor	4/rev	0.34	23.6
	Main rotor	6/rev	0.31	35.4
	Main rotor	8/rev	0.39	47.2
	Main rotor	10/rev	0.38	59.0
	Main rotor	12/rev	0.44	70.8
	Tail rotor	2/rev	0.42	87.6
	Unknown		0.42	121.0
	Engine and tail rotor shaft	Fundamental	0.43	121.0
80-kt descent at 500 ft/min	Main rotor	6/rev	0.8	35.4
	Tail rotor	12/rev	1.87	525.6
S-turns at 100 kt and 45° bank angle	Main rotor	2/rev	0.05	11.8

[1]Dashes indicate values less than 10 percent.

FIGURE 26
250C20B ENGINE LATERAL AXIS VIBRATION

FLIGHT CONDITION	ACCELEROMETER LOCATION	SOURCE		MAXIMUM AVERAGE ACCELERATION (g)	FREQUENCY (Hz)
Ground idle	Gearbox	Note[1]		---	---
	Compressor	---	---	---	---
	Fuel nozzle	---	---	---	---
Hover (IGE)	Gearbox	Main rotor	2/rev	0.20	11.8
	Compressor	Main rotor	Fundamental	0.08	5.9
	Fuel nozzle	N_1	Fundamental	4.32	852.0
	Fuel nozzle	Main rotor	12/rev	0.34	70.8
Normal takeoff	Gearbox	Main rotor	Fundamental	0.19	5.9
	Gearbox	Main rotor	2/rev	0.17	11.8
	Gearbox	Main rotor	4/rev	0.14	23.6
	Fuel nozzle	Main rotor	Fundamental	0.48	5.9
	Fuel nozzle	Main rotor	2/rev	0.43	11.8
	Fuel nozzle	Main rotor	4/rev	0.34	23.6
	Fuel nozzle	Main rotor	6/rev	0.29	35.4
	Compressor	Main rotor	Fundamental	0.15	5.9
Level flight at 80 kt	Gearbox	Main rotor	Fundamental	0.34	5.9
	Compressor	Main rotor	2/rev	0.29	11.8
	Fuel nozzle	Main rotor	6/rev	0.34	35.4
	Fuel nozzle	Main rotor	Fundamental	0.23	5.9
	Fuel nozzle	N_1	Fundamental	4.2	852.0
50-kt climb at 500 ft/min	Compressor	---	---	---	---
	Gearbox	---	---	---	---
	Fuel nozzle	---	---	---	---
80-kt climb at 500 ft/min	Compressor	---	---	---	---
	Gearbox	---	---	---	---
	Fuel nozzle	---	---	---	---
80-kt climb at maximum power	Gearbox	Main rotor	Fundamental	0.18	5.9
	Fuel nozzle	Main rotor	Fundamental	1.4	5.9
	Fuel nozzle	Main rotor	2/rev	1.36	11.8
	Fuel nozzle	Main rotor	4/rev	1.18	23.6
	Fuel nozzle	Main rotor	6/rev	0.72	35.4
	Fuel nozzle	Tail rotor	Fundamental	0.53	43.0
	Fuel nozzle	Main rotor	12/rev	0.98	70.8
50-kt descent at 500 ft/min	Gearbox	Main rotor	2/rev	0.06	11.8
	Gearbox	Main rotor	2/rev	0.07	11.8
	Fuel nozzle	---	---	---	---
80-kt descent at 500 ft/min	Gearbox	Main rotor	Fundamental	0.17	5.9
	Gearbox	Main rotor	2/rev	0.13	11.8
	Compressor	Main rotor	2/rev	0.09	11.8
	Fuel nozzle	Main rotor	2/rev	0.14	11.8
	Fuel nozzle	Tail rotor	Fundamental	0.97	43.8
S-turns at 100 kt and 45° bank angle	Gearbox	Main rotor	Fundamental	0.08	5.9
	Compressor	Main rotor	Fundamental	0.04	5.9
Right 90° turn at 100 kt and 45° bank angle	Fuel nozzle	Main rotor	Fundamental	0.2	5.9
	Compressor	Main rotor	Fundamental	0.15	5.9
	Gearbox	Main rotor	Fundamental	0.16	5.9

[1]Dashes indicate values less than 10 percent.

FIGURE 27
250C20B ENGINE VERTICAL AXIS VIBRATION

FLIGHT CONDITION	ACCELEROMETER LOCATION	SOURCE		MAXIMUM AGERAGE ACCELERATION (g)	FREQUENCY (Hz)
Ground-idle	Gearbox	Note[1]		---	---
	Turbine	---	---	---	---
	Fuel nozzle	---	---	---	---
Flight-idle	Fuel nozzle	Main rotor	Fundamental	0.12	5.9
	Compressor	Main rotor	2/rev	0.08	11.8
	Fuel nozzle	Unknown		3.8	635.0
Hover IGE	Turbine	---	---	---	---
	Gearbox	---	---	---	---
	Compressor	---	---	---	---
	Fuel nozzle	Main rotor	Fundamental	0.21	5.9
Normal takeoff	Gearbox	Main rotor	Fundamental	0.16	5.9
	Turbine	Main rotor	Fundamental	0.39	5.9
	Turbine	Main rotor	2/rev	0.31	11.8
	Turbine	Main rotor	4/rev	0.18	23.6
	Fuel nozzle	Main rotor	2/rev	1.0	11.8
	Fuel nozzle	Main rotor	4/rev	0.80	23.6
	Compressor	Main rotor	Fundamental	1.0	5.9
	Compressor	Main rotor	2/rev	0.46	11.8
	Compressor	Unknown		0.18	18.0
Level flight at 80 kt	Fuel nozzle	Main rotor	Fundamental	0.64	5.9
	Fuel nozzle	Main rotor	2/rev	0.69	11.8
	Fuel nozzle	Main rotor	4/rev	0.62	23.6
	Fuel nozzle	Main rotor	6/rev	0.60	35.4
	Fuel nozzle	Main rotor	10/rev	0.94	59.0
	Fuel nozzle	Unknown		0.94	121.0
	Fuel nozzle	Tail rotor	4/rev	0.84	175.0
	Turbine	Main rotor	Fundamental	0.07	5.9
	Compressor	Tail rotor	Fundamental	0.13	43.8
50-kt climb at 500 ft/min	Gearbox	---	---	---	---
	Compressor	---	---	---	---
	Fuel nozzle	---	---	---	---
80-kt climb at 500 ft/min	Gearbox	---	---	---	---
	Compressor	---	---	---	---
	Fuel nozzle	---	---	---	---
80-kt climb at maximum power	Turbine	Main rotor	Fundamental	1.76	11.8
	Turbine	Main rotor	2/rev	1.46	23.6
	Turbine	Main rotor	4/rev	1.04	35.4
	Turbine	Tail rotor	Fundamental	0.68	43.8
	Turbine	Main rotor	10/rev	0.60	59.0
	Turbine	Main rotor	12/rev	0.42	70.8
	Turbine	Tail rotor	2/rev	0.29	87.6
	Turbine	Main rotor	8/rev	0.65	47.2
50-kt descent at 500 ft/min	Gearbox	---	---	---	---
	Compressor	---	---	---	---
	Fuel nozzle	---	---	---	---
80-kt descent at 500 ft/min	Turbine	Main rotor	Fundamental	0.52	5.9
	Turbine	Main rotor	2/rev	0.32	11.8
	Turbine	Tail rotor	Fundamental	0.44	43.8
	Turbine	Main rotor	10/rev	0.91	59.0
	Turbine	Unknown		0.86	121.0
	Compressor	Main rotor	6/rev	0.23	35.9
S-turns at 100 kt and 95° bank angle	Gearbox	Unknown		2.1	121.0
	Turbine	---	---	---	---
	Fuel nozzle	---	---	---	---

[1]Dashes indicate values less than 10 percent.

FIGURE 28
250-C20B ENGINE TEMPERATURE SURVEY (°C)

TEMPERATURE PROBE LOCATION	FLIGHT CONDITION							MAXIMUM PERMISSIBLE OPERATING TEMPERATURE
	LEVEL FLIGHT		MAXIMUM POWER CLIMB		500 FPM DESCENT		GROUND-IDLE	
---	80 KCAS	V_{NE} 105 KCAS	50 KCAS	80 KCAS	50 KCAS	80 KCAS	---	---
Compressor section	54.0 (98.2)	52.0 (97.2)	52.0 (97.2)	52.0 (93.4)	47.0 (90.3)	54.5 (97.5)	52.0 (102.5)	135
Gearbox section	49.0 (92.5)	36.0 (79.0)	43.5 (87.5)	52.0 (93.4)	43.5 (86.3)	52.0 (94.7)	54.5 (105.4)	121
Turbine and combustor section	123.0 (176.5)	149.0 (207.7)	126.5 (182.1)	123.0 (173.4)	126.5 (180.5)	123.0 (175.0)	126.5 (188.6)	232
Top engine mount pad surface	---	52.0 (97.2)	---	---	---	---	---	160
Ignition harness surface	123.0 (176.5)	149.0 (207.7)	121.0 (175.8)	123.0 (173.4)	126.5 (180.5)	123.0 (175.0)	123.0 (184.5)	232
Thermocouple harness surface	107.0 (158.4)	82.0 (131.4)	90.5 (141.1)	96.0 (143.0)	79.5 (127.2)	90.5 (138.2)	93.5 (150.4)	315
Oil cooler temperature (oil temperature exiting cooler)	75.0 (122.0)	---	82.0 (131.4)	78.5 (123.2)	73.0 (119.8)	73.5 (119.0)	62.5 (114.6)	107
Maximum ambient tmeperature	13.0	12.0	12.0	15.0	13.0	14.0	8.0	52
Pressure altitude (feet)	6040	5880	6560	4520	4220	5220	2560	---

NOTE: Values in parentheses are corrected to the Army's maximum design requirement ambient temperature of 125°F (52°C).

FIGURE 29

ENGINE ACCELERATION AND DECELERATION TESTS

OH-58A USA S/N 18708
MODEL 250 C-20B ENGINE

GROSS WEIGHT ~LB	CG LOCATION ~IN	DENSITY ALTITUDE ~FT	OAT ~DEG C	ROTOR SPEED ~RPM	AIRSPEED ~KCAS	CT	CONFIGURATION
3115	107.7 (FWD)	2300	12.5	347	0	.003218	CLEAN - DOORS ON

NOTE: COLLECTIVE CONTROL CYCLED AT 3.1 HZ NEAR THE AIRCRAFT NATURAL FREQUENCY.

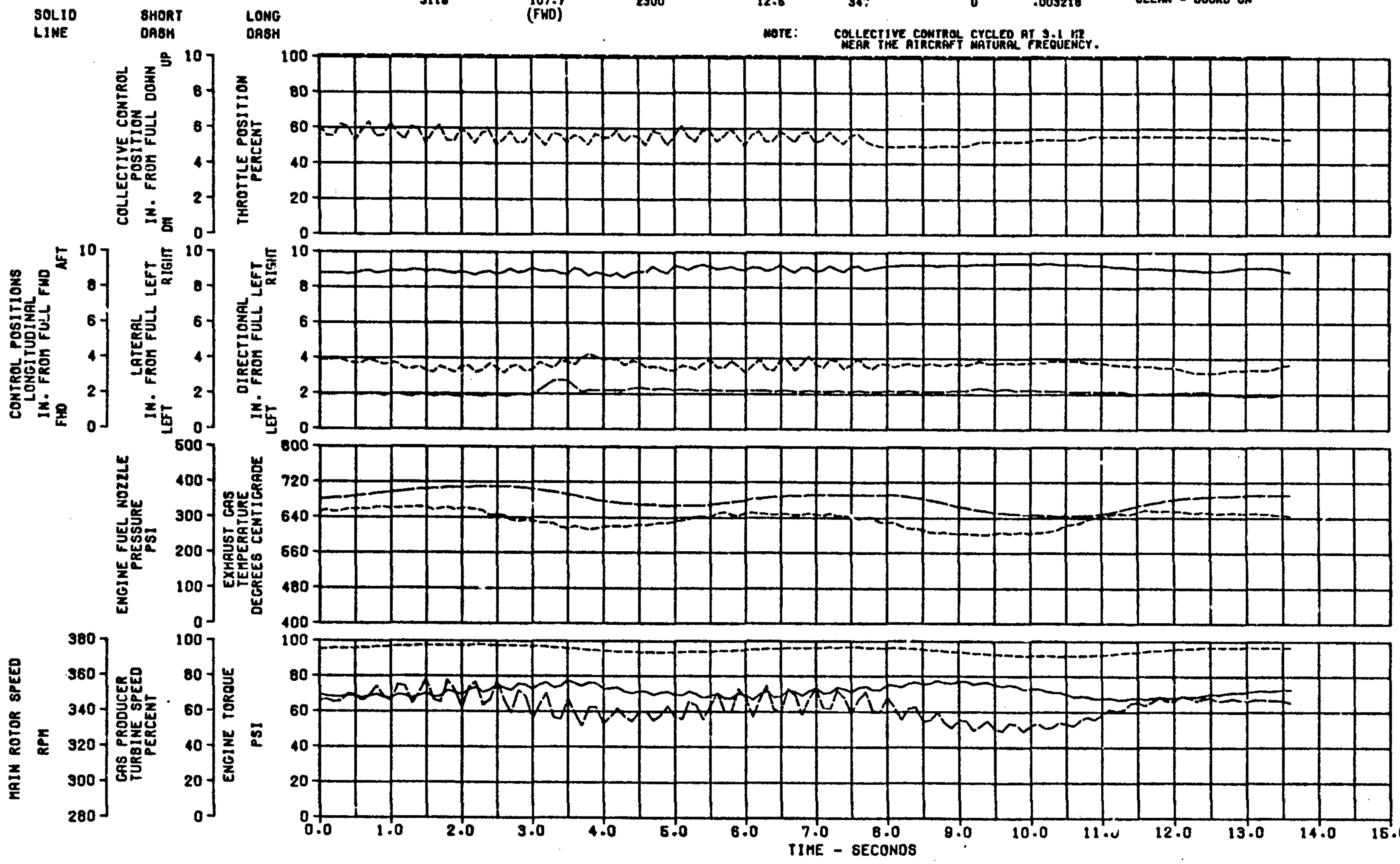


FIGURE 30

ENGINE ACCELERATION AND DECELERATION TESTS

OH-58A USA S/N 16706
MODEL 250 C-20B ENGINE

GROSS WEIGHT ~LB	CG LOCATION ~IN	DENSITY ALTITUDE ~FT	OAT ~DEG C	ROTOR SPEED ~RPM	AIRSPEED ~KCAS	CT	CONFIGURATION
3115	107.7 (FWD)	2260	12.0	354	0	.003127	CLEAN - DOORS ON

NOTE COLLECTIVE CONTROL CYCLED AT 2.9 HZ NEAR THE AIRCRAFT NATURAL FREQUENCY.

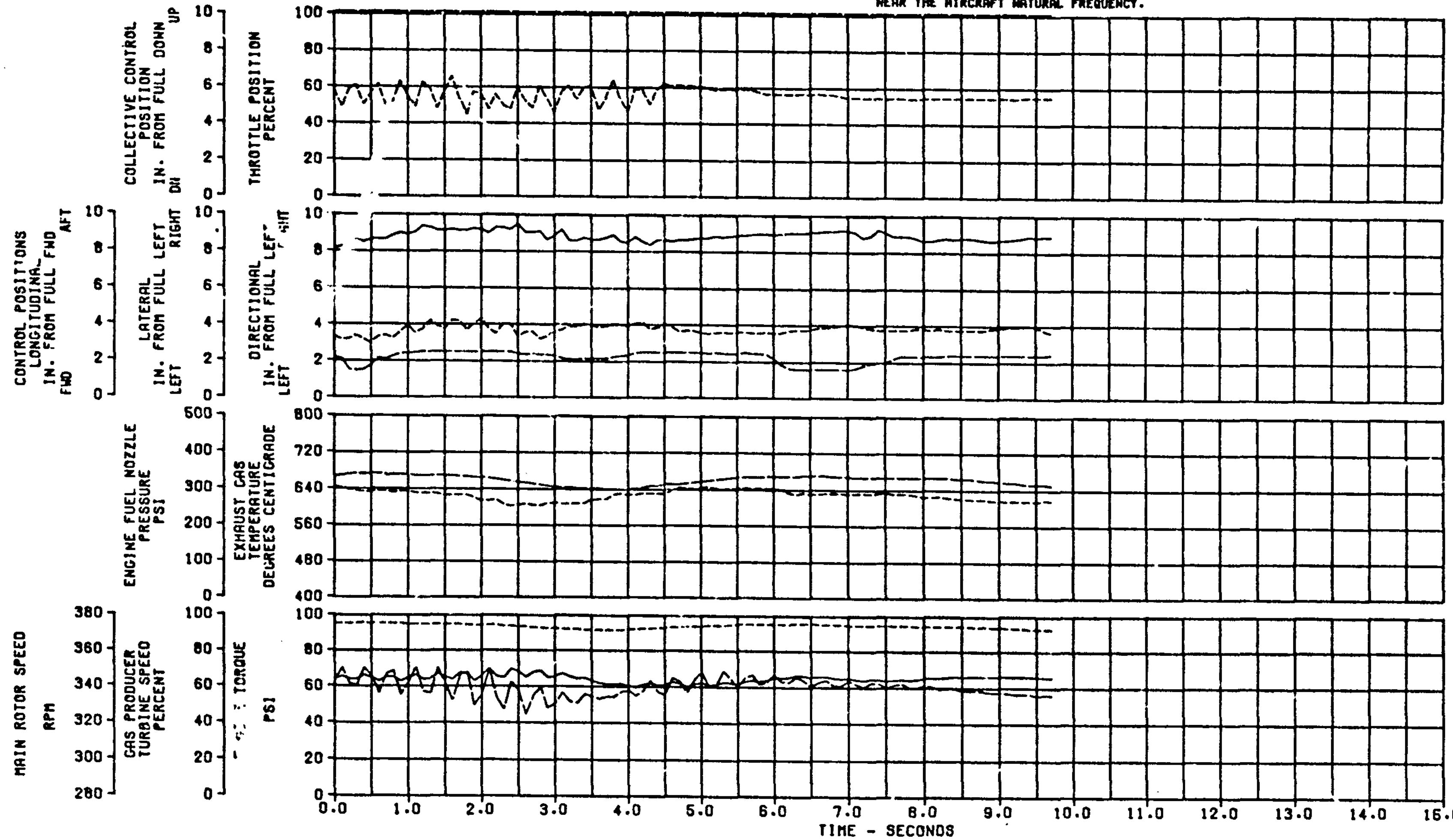


FIGURE 31

ENGINE ACCELERATION AND DECELERATION TESTS

OH-58A USA S/N 18706
MODEL 250 C-20B ENGINE

GROSS WEIGHT ~LB	CG LOCATION ~IN	DENSITY ALTITUDE ~FT	OAT ~DEG C	ROTOR SPEED ~RPM	AIRSPEED ~KCAS	CT	CONFIGURATION
3115	107.7 (FWD)	2260	12.0	354	0	.003127	CLEAN - DOORS ON

NOTE COLLECTIVE CONTROL CYCLED AT 2.9 HZ NEAR THE AIRCRAFT NATURAL FREQUENCY.

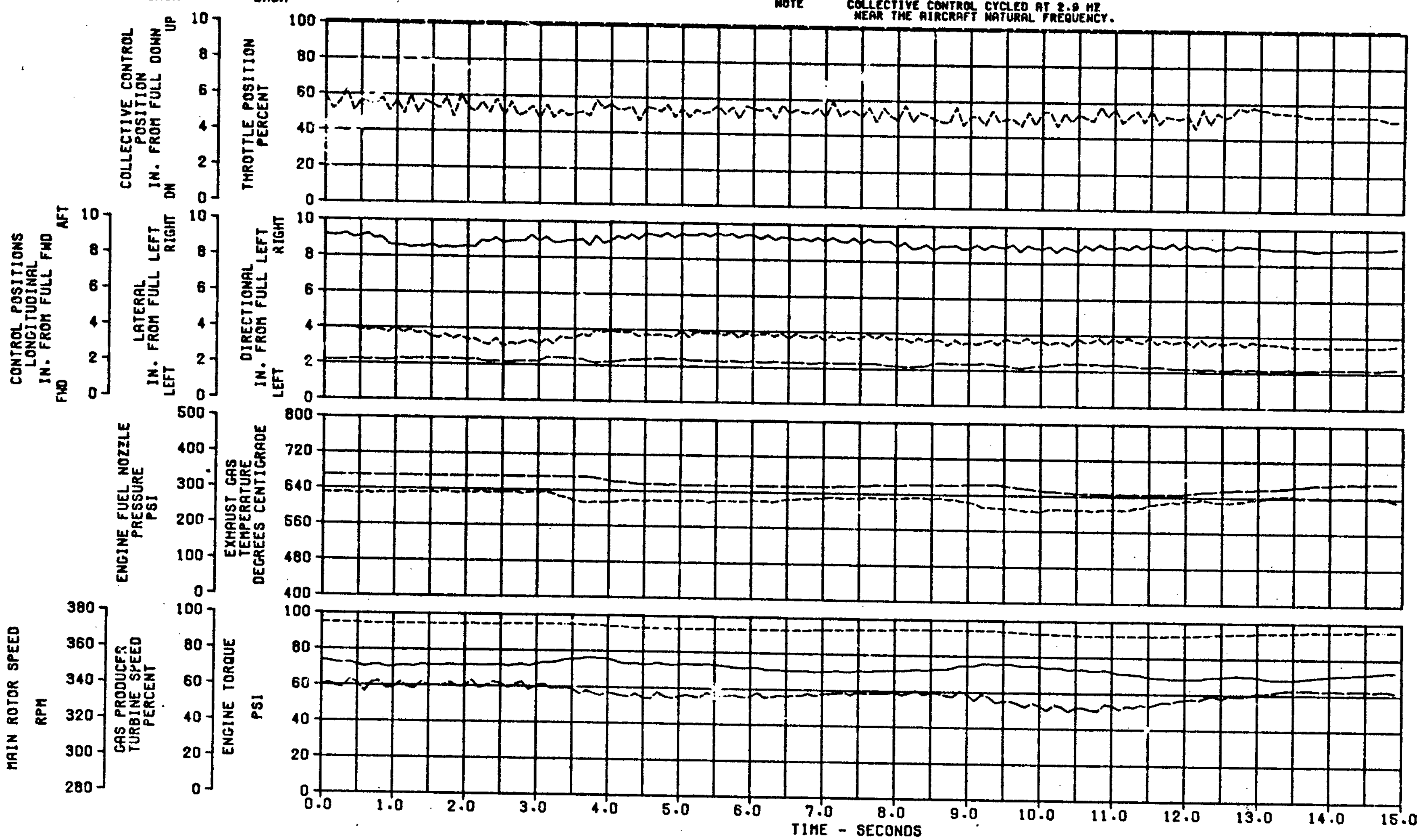


FIGURE 32

ENGINE ACCELERATION AND DECELERATION TESTS

OH-58A USA S/N 16706
MODEL 250 C-20B ENGINE

GROSS WEIGHT ~LB	CG LOCATION ~IN	DENSITY ALTITUDE ~FT	OAT ~DEG C	ROTOR SPEED ~RPM	AIRSPEED ~KCAS	CT	CONFIGURATION
3105	107.7 (FWD)	2280	12.0	347	0	.003207	CLEAN - DOORS ON

NOTE DIRECTIONAL CONTROL CYCLED AT 2.1 HZ -NEAR THE AIRCRAFT NATURAL FREQUENCY.

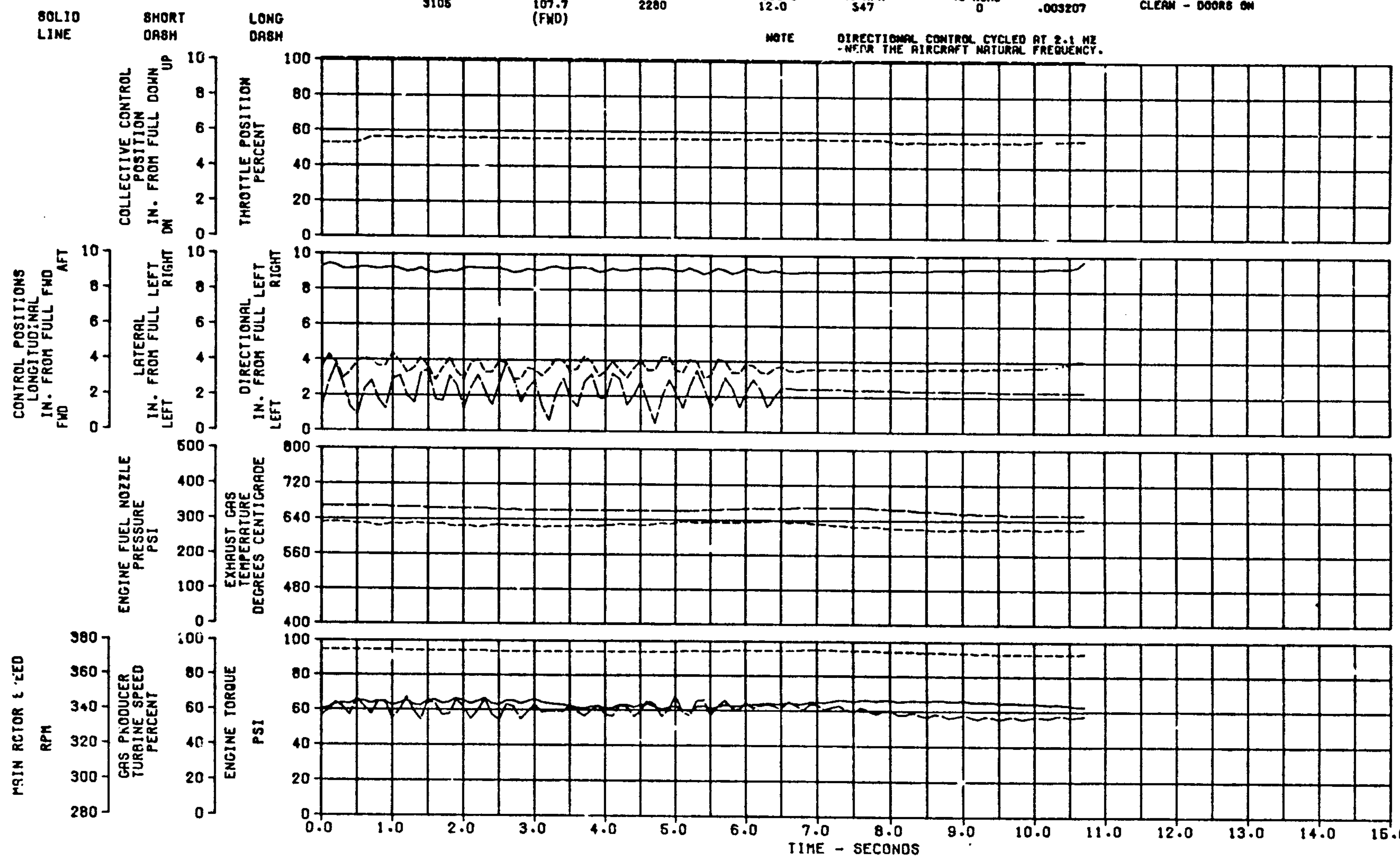


FIGURE 33
ENGINE ACCELERATION AND DECELERATION TESTS
SH-58A USA S/N 18708
MODEL 250 C-30R ENGINE

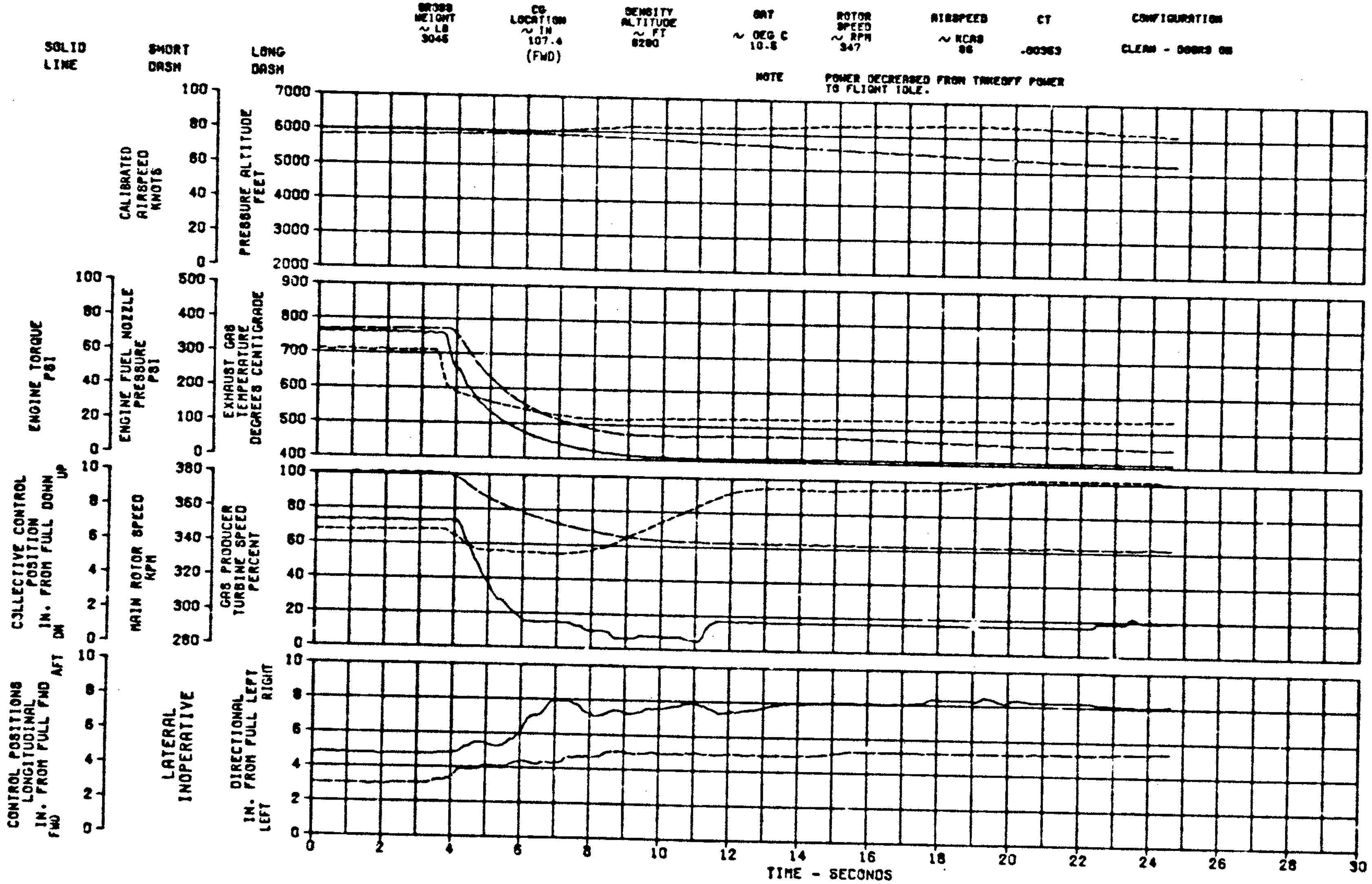


FIGURE 34
ENGINE ACCELERATION AND DECELERATION TESTS
OH-58A USA S/N 16706
MODEL 250 C-20B ENGINE

GROSS WEIGHT ~ LB	CG LOCATION ~ IN	DENSITY ALTITUDE ~ FT	OAT ~ DEG C	ROTOR SPEED ~ RPM	AIRSPEED ~ KCAS	CT	CONFIGURATION
3065	107.7 (FWD)	5940	11.5	349	87	.00379	CLEAN - DOORS ON

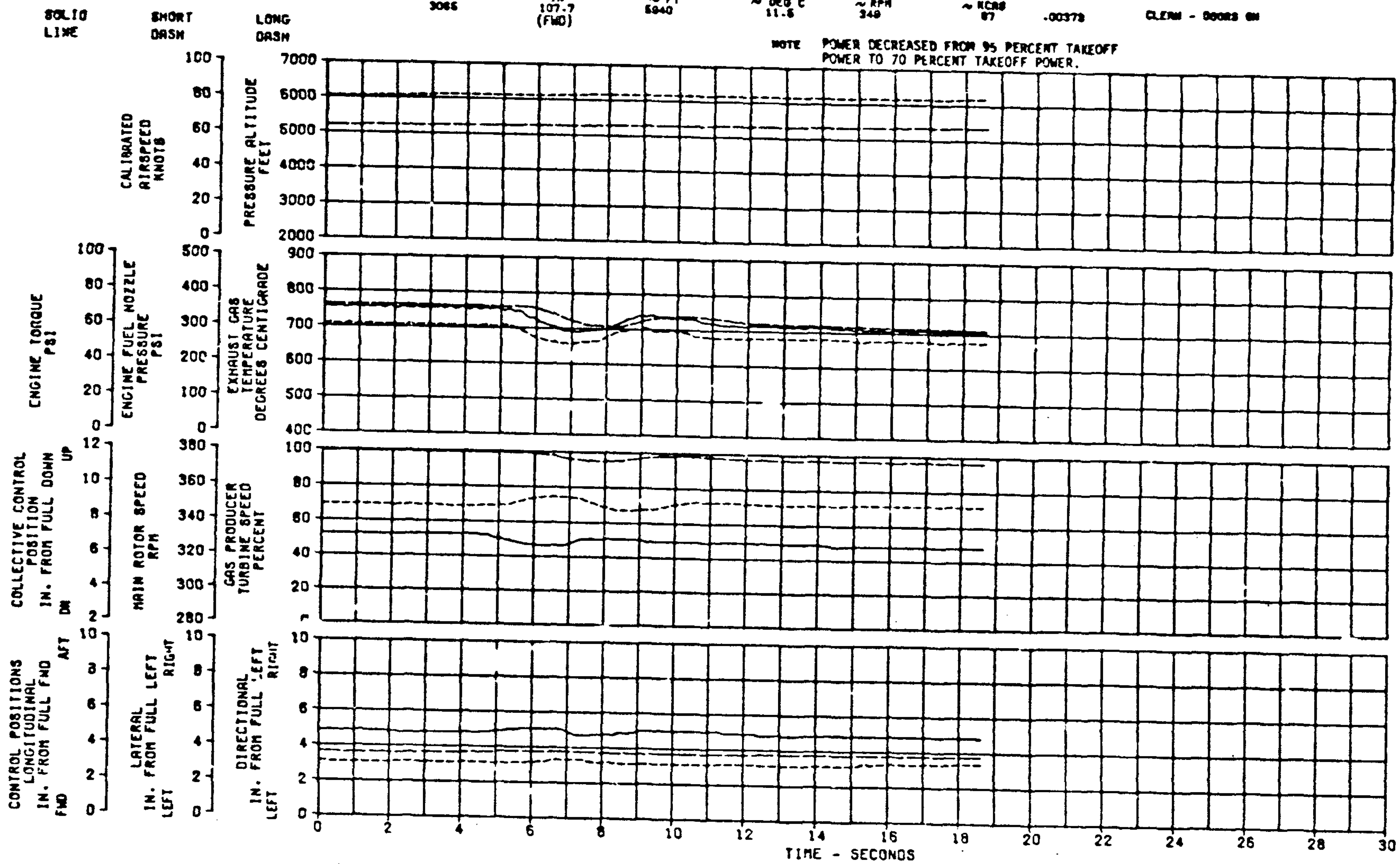


FIGURE 35
ENGINE ACCELERATION AND DECELERATION TESTS
OH-58A USA S/N 16706
MODEL 250 C-20B ENGINE

GROSS WEIGHT ~ LB	CG LOCATION ~ IN	DENSITY ALTITUDE ~ FT	OAT ~ DEG C	ROTOR SPEED ~ RPM	AIRSPEED ~ KCAS	CT	CONFIGURATION
3030	107.4 (FWD)	6820	11.0	352	88	.003203	CLEAN - DOORS ON

NOTE: POWER INCREASED FROM 70 PERCENT OF TRANSMISSION TORQUE LIMITATION TO 100 PERCENT TRANSMISSION TORQUE LIMITATION.

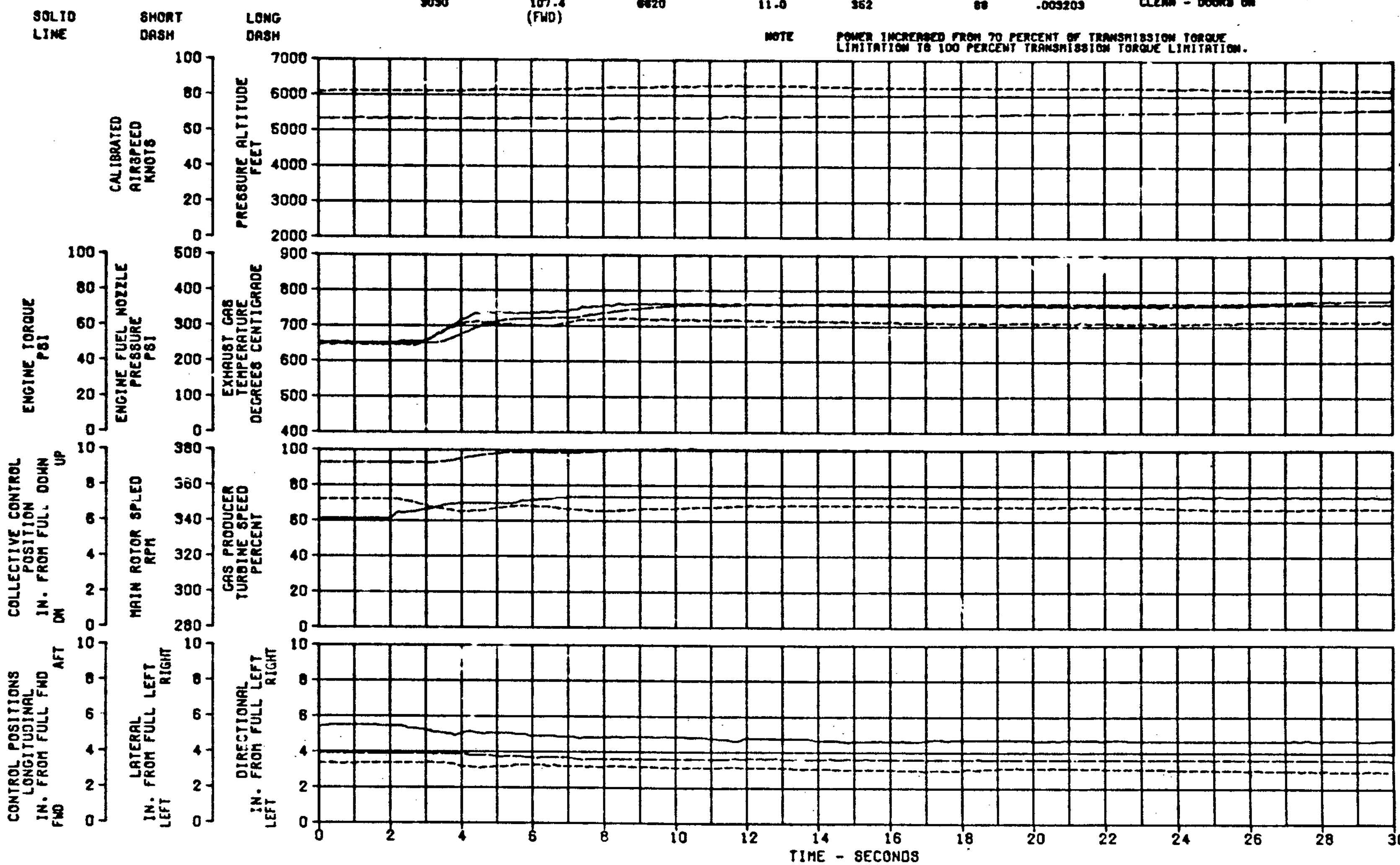


FIGURE 36
ENGINE ACCELERATION AND DECELERATION TESTS
OH-58A USA S/N 18706
MODEL 250 C-20B ENGINE

GROSS WEIGHT ~ LB	CG LOCATION ~ IN	DENSITY ALTITUDE ~ FT	OAT ~ DEG C	ROTOR SPEED ~ RPM	AIRSPEED ~ KCAS	CT	CONFIGURATION
3015	107.3 (FWD)	5120	11.5	381	57	.002829	CLEAN - DOORS ON

NOTE: POWER INCREASED FROM FLIGHT IDLE TO 96 PERCENT OF ENGINE TAKEOFF POWER.

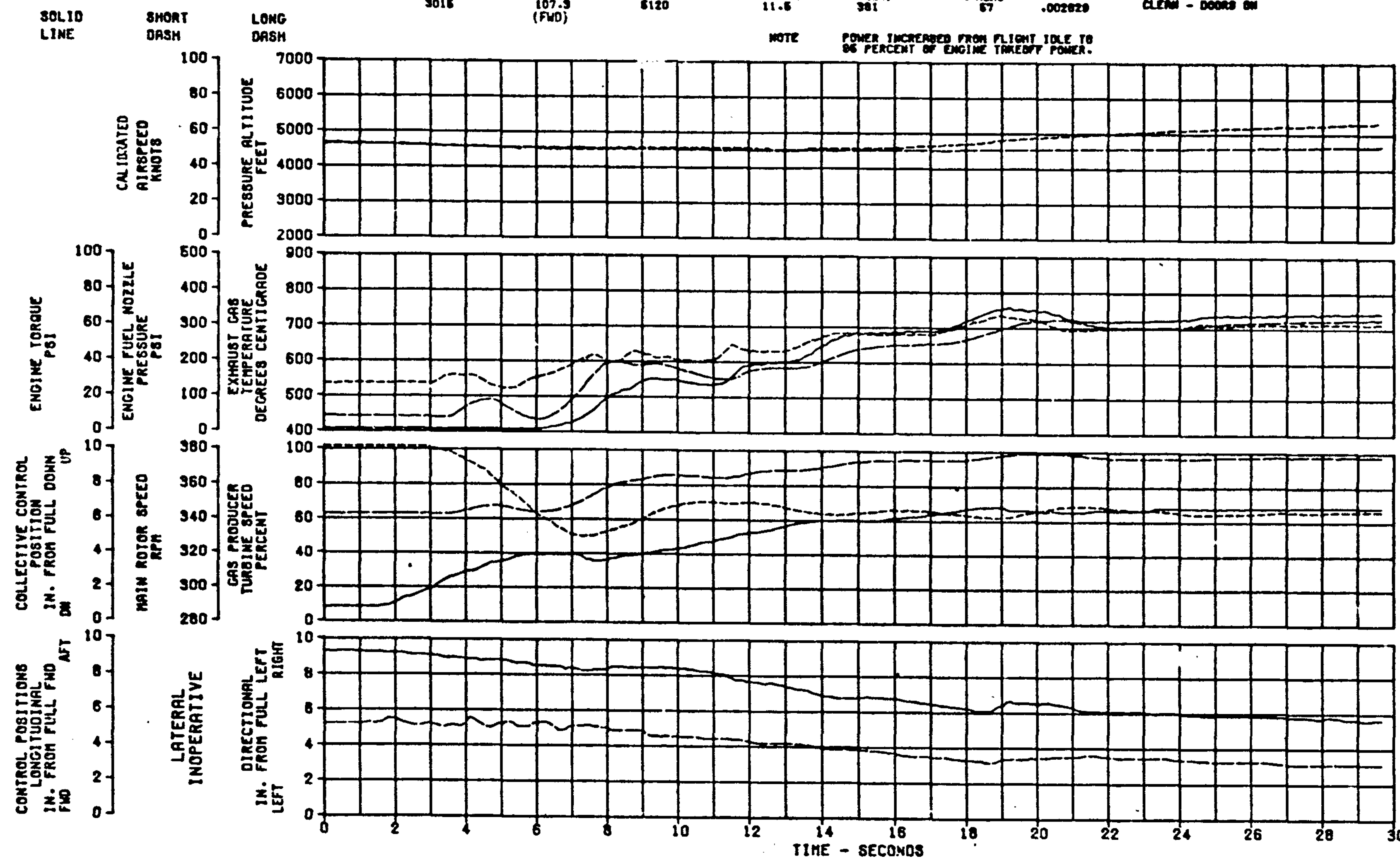


FIGURE 37
ENGINE ACCELERATION AND DECELERATION TESTS
OH-58A USA S/N 18706
MODEL 250 C-20B ENGINE

GROSS WEIGHT ~ LB	CG LOCATION ~ IN	DENSITY ALTITUDE ~ FT	OAT ~ DEG C	ROTOR SPEED ~ RPM	AIRSPEED ~ KCAS	CT	CONFIGURATION
3015	107.2 (FWD)	6220	10.0	347	46	.003171	CLEAN - DOORS ON

NOTE POWER DECREASED FROM 96 PERCENT TAKEOFF POWER TO FLIGHT IDLE.

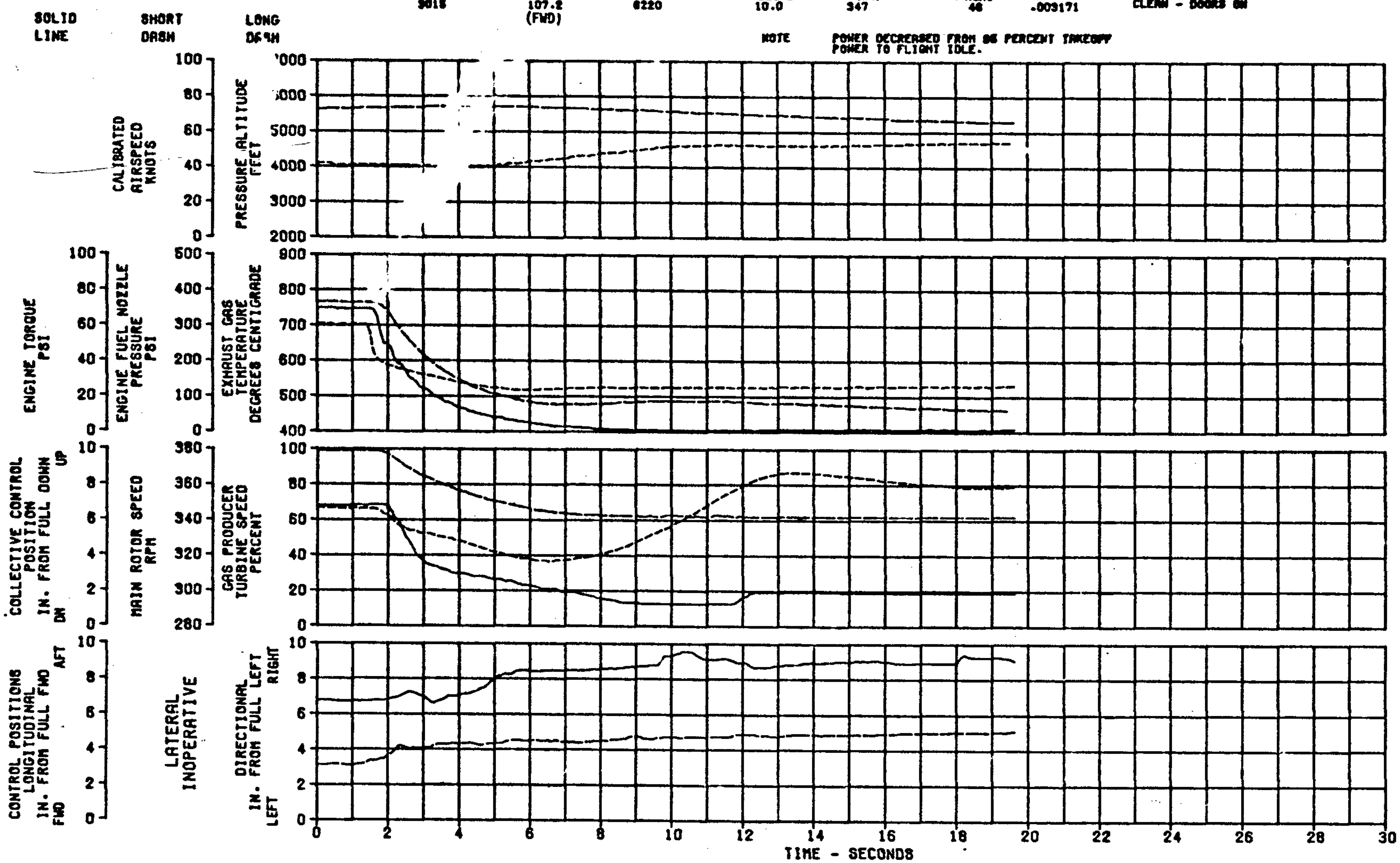


FIGURE 38

ENGINE ACCELERATION AND DECELERATION TESTS

OH-58A USA S/N 16706
MODEL 260 C-20B ENGINE

GROSS WEIGHT ~ LB	CG LOCATION ~ IN	DENSITY ALTITUDE ~ FT	OAT ~ DEG C	ROTOR SPEED ~ RPM	AIRSPEED ~ KCAS	CT	CONFIGURATION
3015	107.2 (FWD)	6140	12.0	355	57	.003024	CLEAN - DOORS ON

NOTE POWER INCREASED FROM FLIGHT IDLE TO 100 PERCENT TAKEOFF POWER.

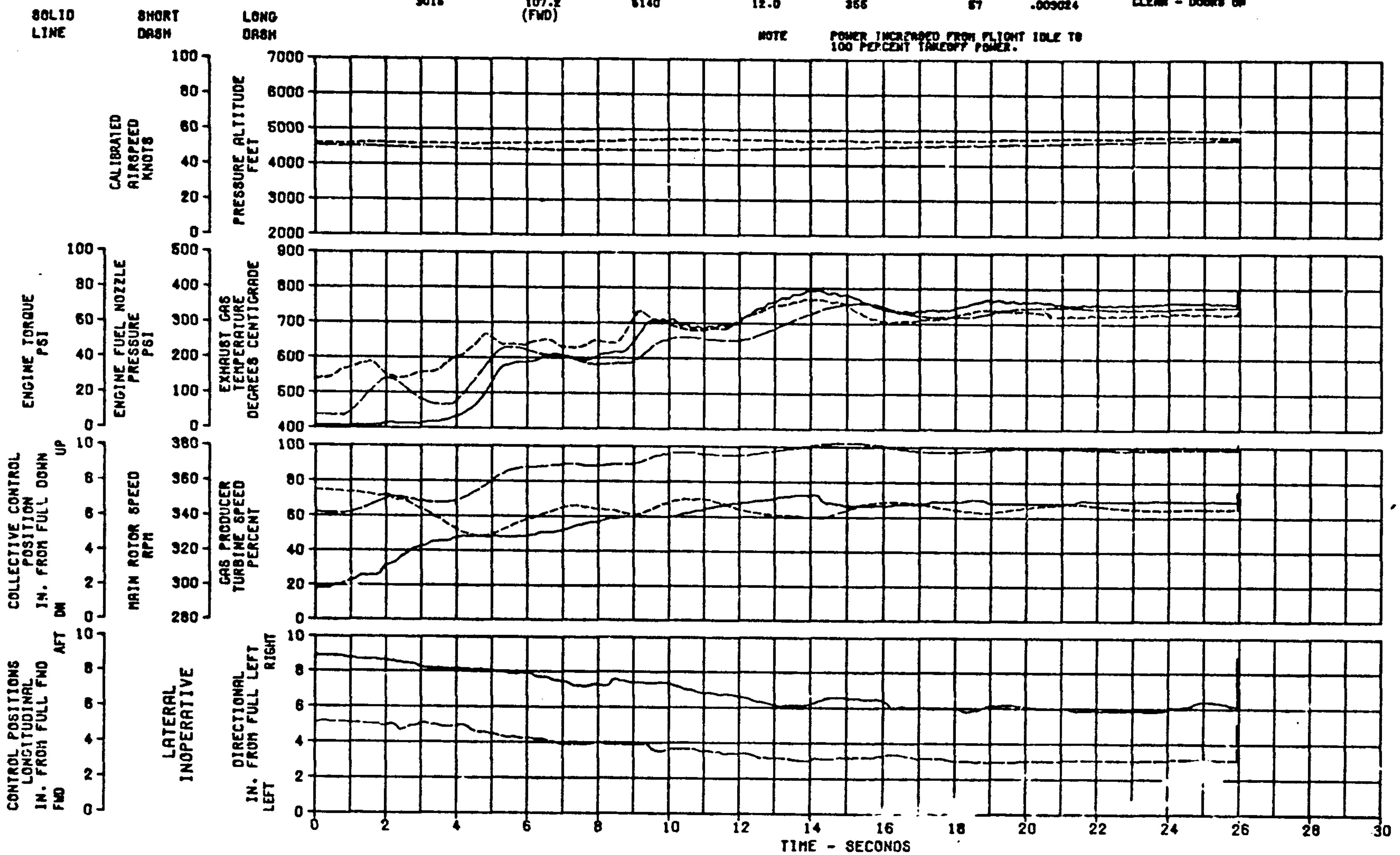


FIGURE 39

ENGINE ACCELERATION AND DECELERATION TESTS

OH-58A USA S/N 16706

MODEL 250 C-20B ENGINE

GROSS WEIGHT ~ LB	CG LOCATION ~ IN	DENSITY ALTITUDE ~ FT	OAT ~ DEG C	ROTOR SPEED ~ RPM	AIRSPEED ~ KCAS	CT	CONFIGURATION
3010	107.2 (FWD)	5780	11.0	347	60	.003164	CLEAN - DOORS ON

NOTE POWER DECREASED FROM 100 PERCENT TAKEOFF POWER TO FLIGHT IDLE.

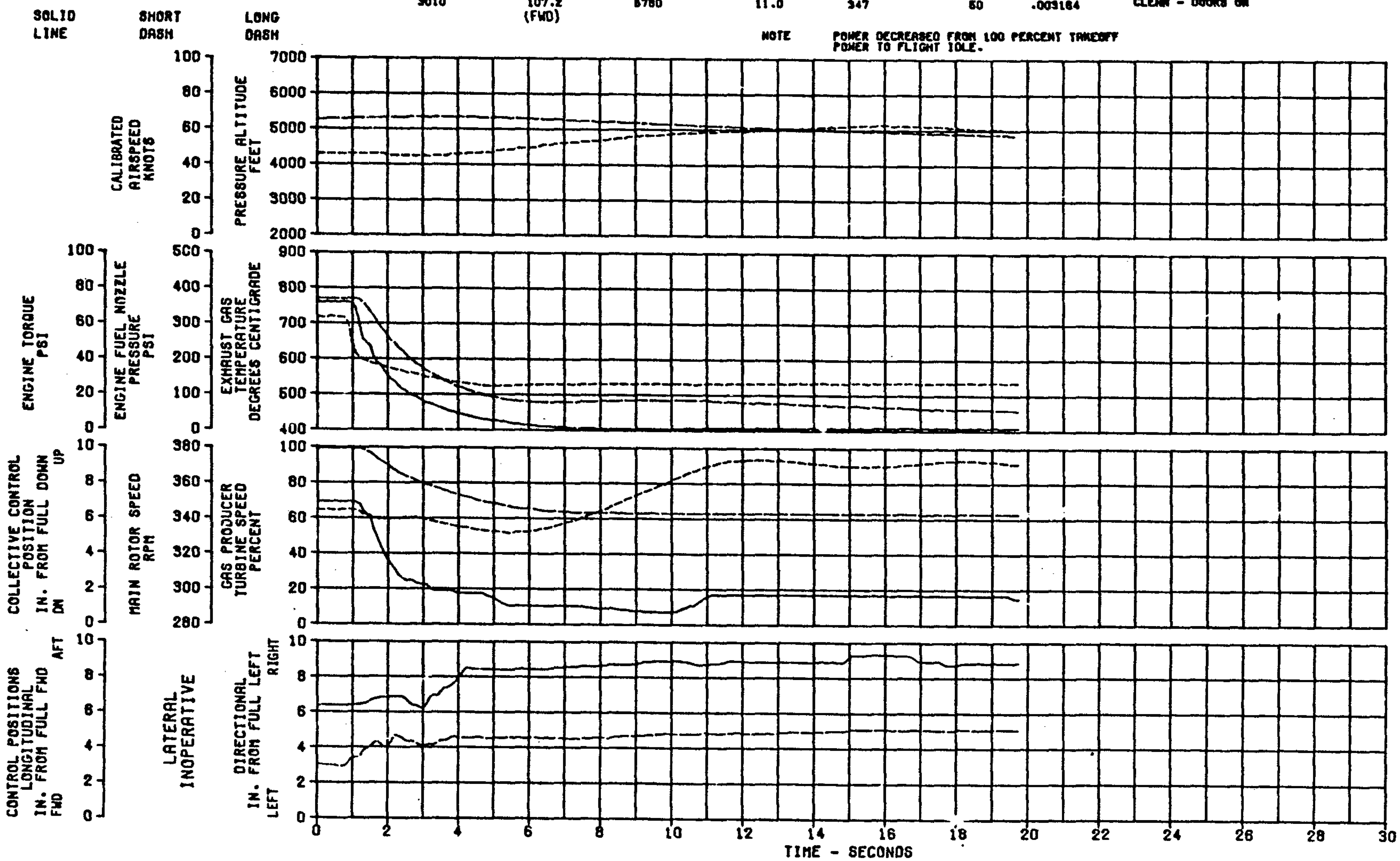


FIGURE 40

ENGINE ACCELERATION AND DECELERATION TESTS

OH-58A USA S/N 16706
MODEL 250 C-20B ENGINE

GROSS WEIGHT ~ LB	CG LOCATION ~ IN	DENSITY ALTITUDE ~ FT	OAT ~ DEG C	ROTOR SPEED ~ RPM	AIRSPEED ~ KCAS	CT	CONFIGURATION
3005	107.2 (FWD)	5540	12.0	348	54	.003121	CLEAN - DOORS ON

NOTE POWER INCREASED FROM 70 PERCENT OF TRANSMISSION TORQUE LIMIT TO 100 PERCENT TAKEOFF POWER.

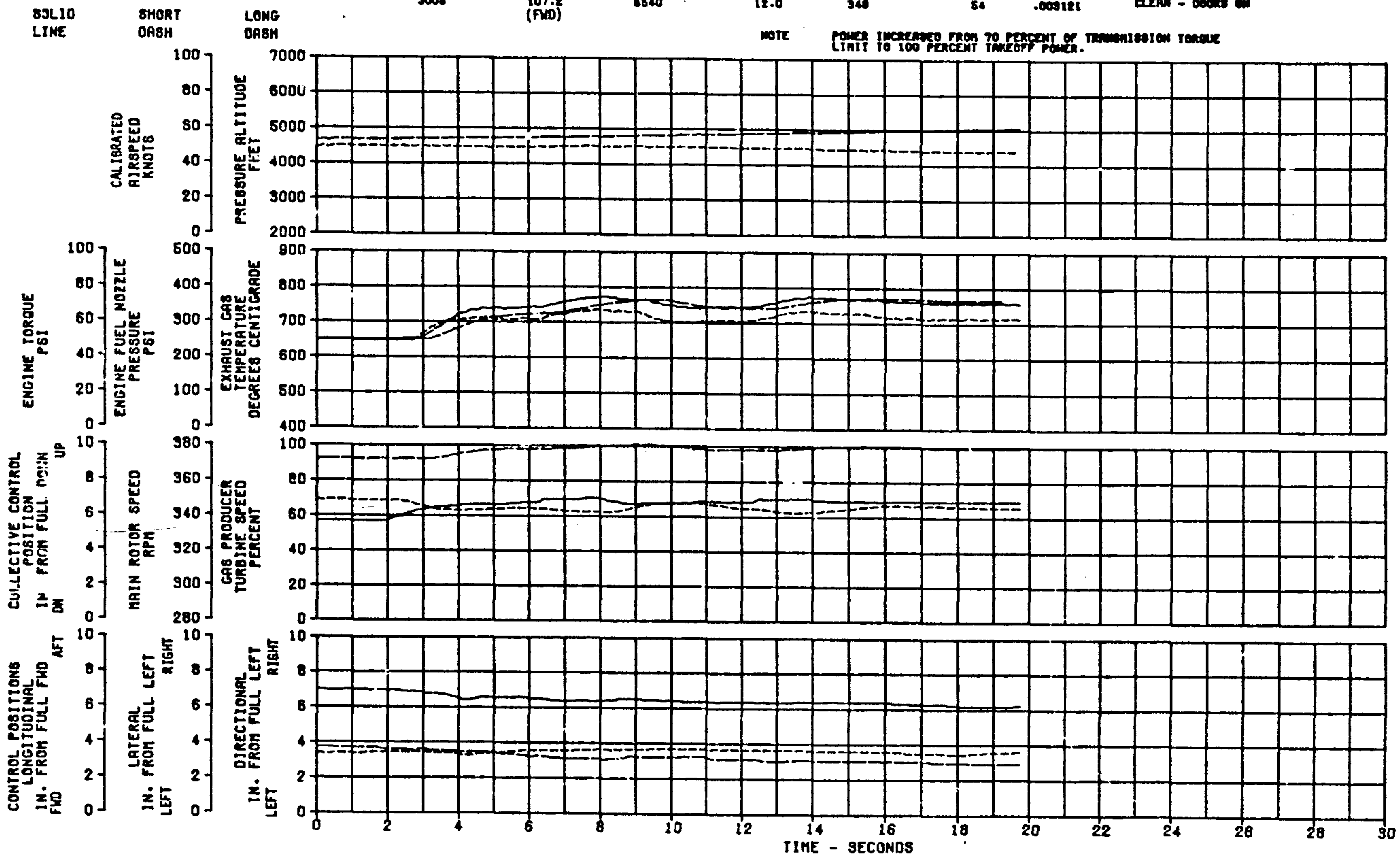


FIGURE 41

ENGINE ACCELERATION AND DECELERATION TESTS

OH-58A USA S/N 16706

MODEL 250 C-20B ENGINE

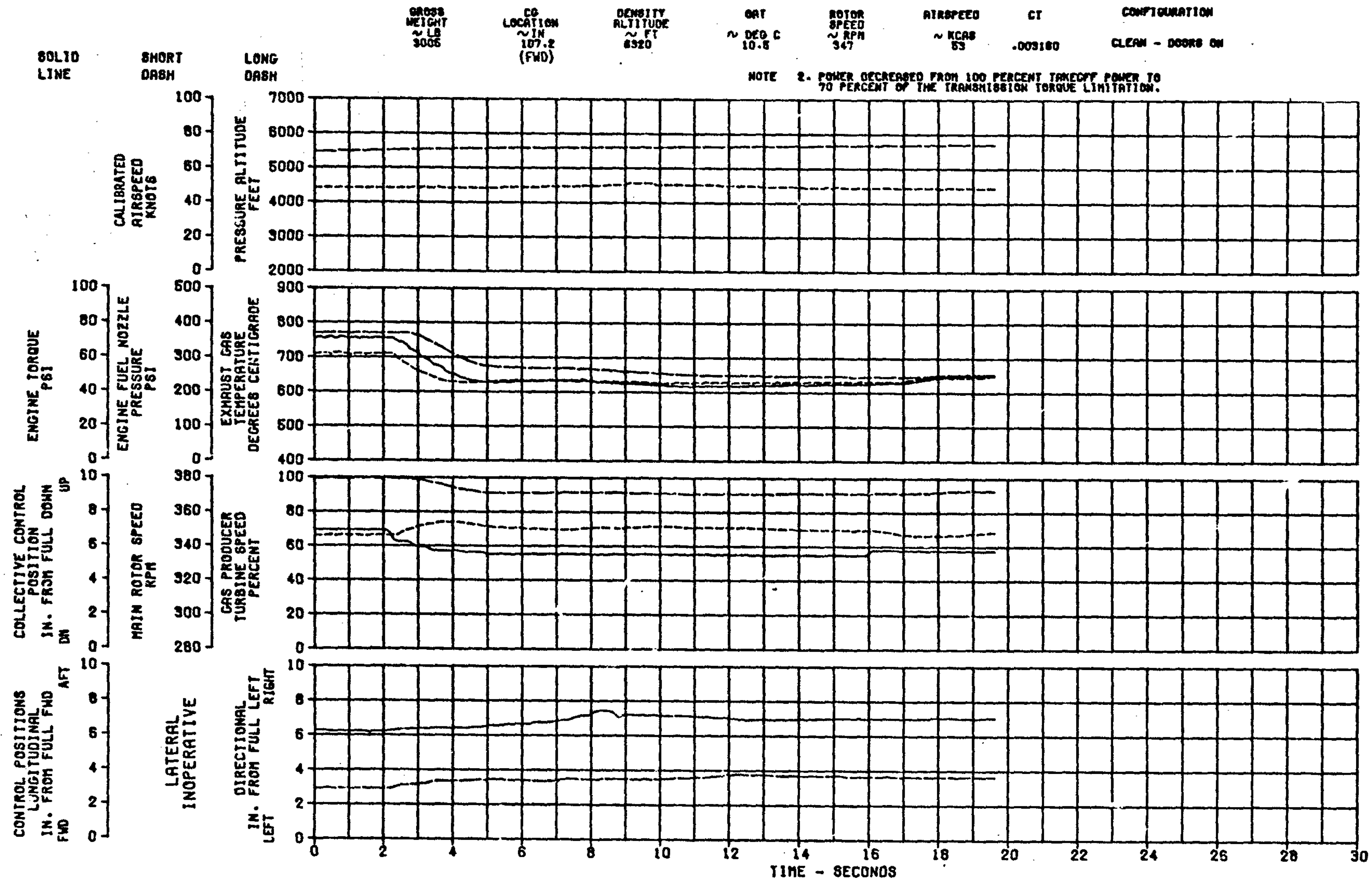


FIGURE 42

ENGINE ACCELERATION AND DECELERATION TESTS

OH-58A USA S/N 16706
MODEL 250 C-20B ENGINE

GROSS WEIGHT ~ LB	CG LOCATION ~ IN	DENSITY ALTITUDE ~ FT	OAT ~ DEG C	ROTOR SPEED ~ RPM	AIRSPEED ~ KCAS	CT	CONFIGURATION
3000	107.2 (FWD)	6940	10.0	348	58	.003137	CLEAN - DOORS ON

NOTE: POWER INCREASED FROM 70 PERCENT OF TRANSMISSION TORQUE LIMIT TO 100 PERCENT TAKEOFF POWER.

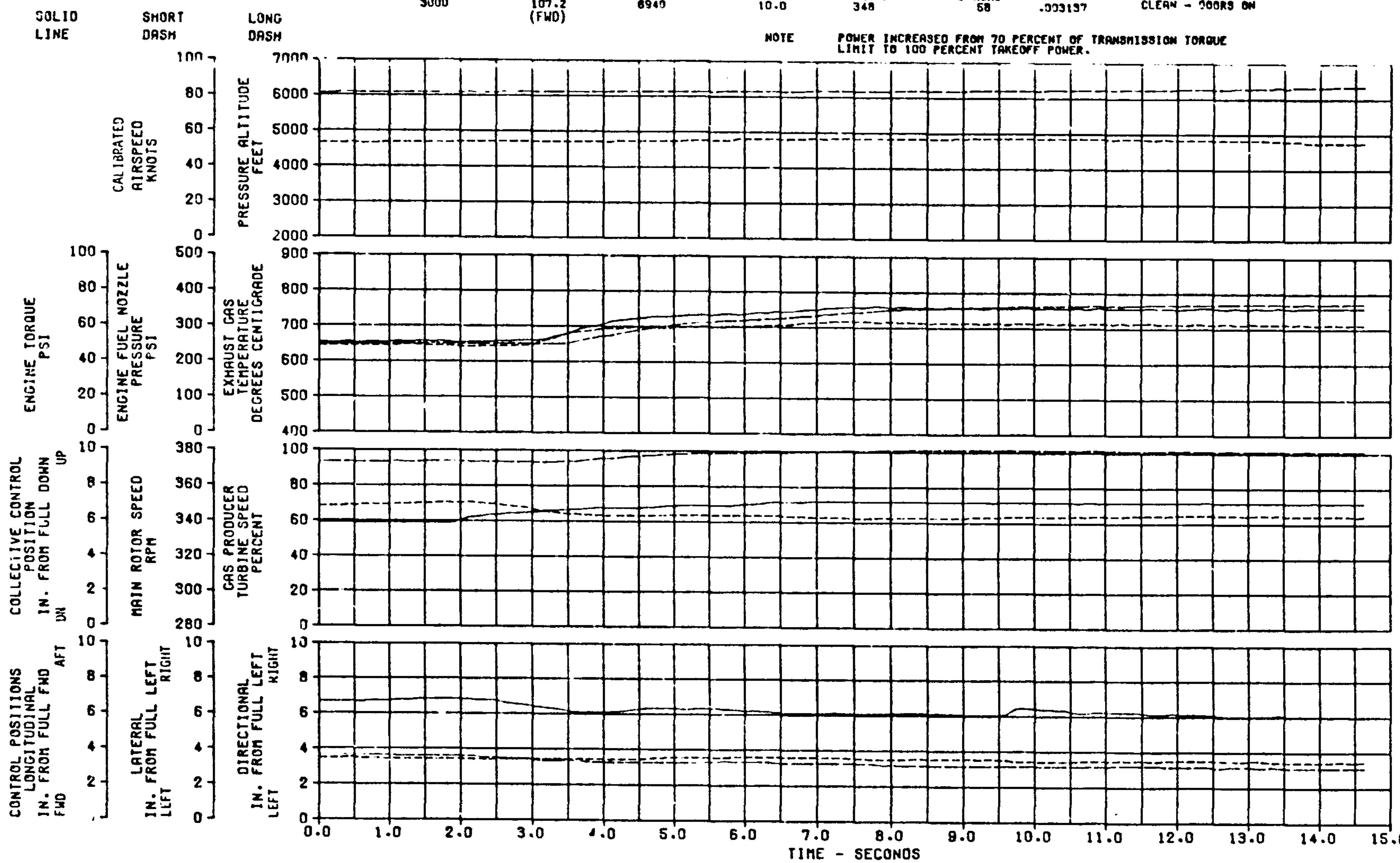


FIGURE 43
ENGINE ACCELERATION AND DECELERATION TESTS
OH-58A USA S/N 16706
MODEL 250 C-20B ENGINE

GROSS WEIGHT ~ LB	CG LOCATION ~ IN	DENSITY ALTITUDE ~ FT	OAT ~ DEG C	ROTOR SPEED ~ RPM	AIRSPEED ~ KCAS	CT	CONFIGURATION
3000	107.2 (FWD)	7460	9.0	347	55	.00385	CLEAN - DOORS ON

NOTE POWER DECREASED FROM 100 PERCENT TAKEOFF POWER TO 70 PERCENT OF THE TRANSMISSION TORQUE LIMITATION.

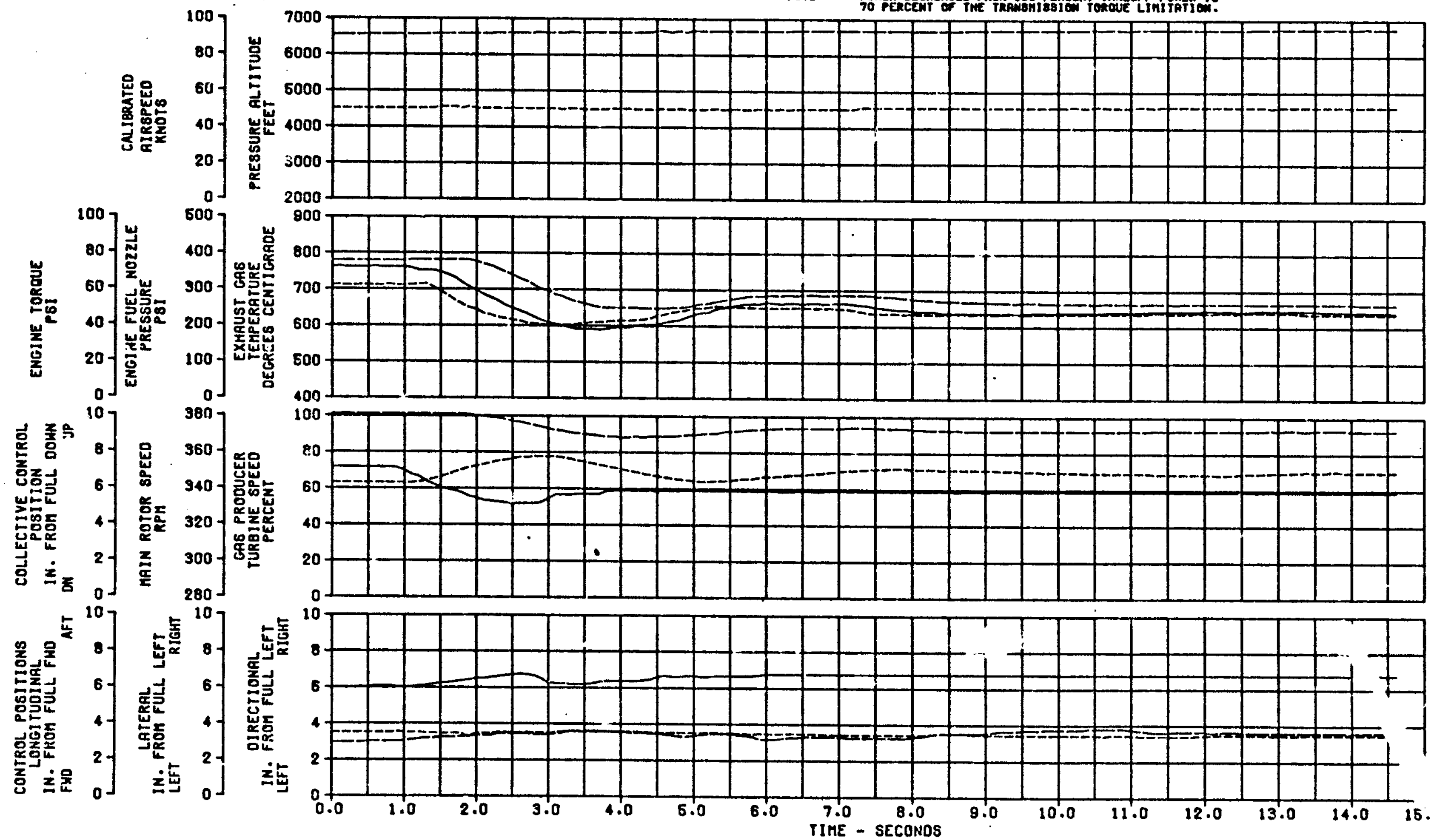


FIGURE 44

ENGINE ACCELERATION AND DECELERATION TESTS

OH-58A USA S/N 16706

MODEL 250 C-20B ENGINE

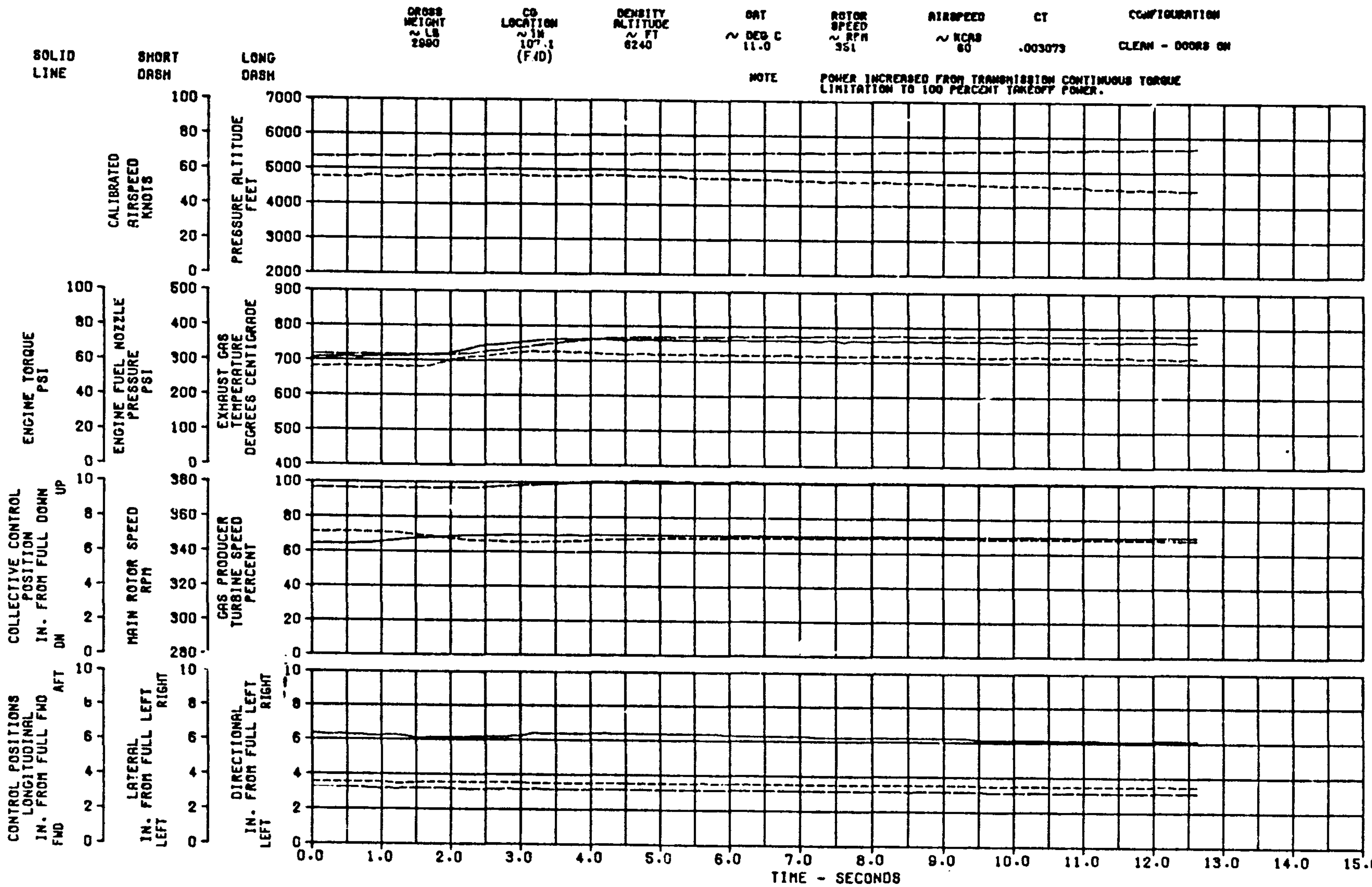


FIGURE 45

ENGINE ACCELERATION AND DECELERATION TESTS

OH-58A USA S/N 1870_
MODEL 250 C-20B ENGINE

GROSS WEIGHT ~ LB	CG LOCATION ~ IN	DENSITY ALTITUDE ~ FT	OAT ~ DEG C	ROTOR SPEED ~ RPM	AIRSPEED ~ KCAS	CT	CONFIGURATION
2985	107.1 (FWD)	6920	10.C	348	51	.003131	CLEAN - DOORS ON

NOTE POWER DECREASED FROM 100 PERCENT TAKEOFF POWER TO THE TRANSMISSION CONTINUOUS TORQUE LIMITATION.

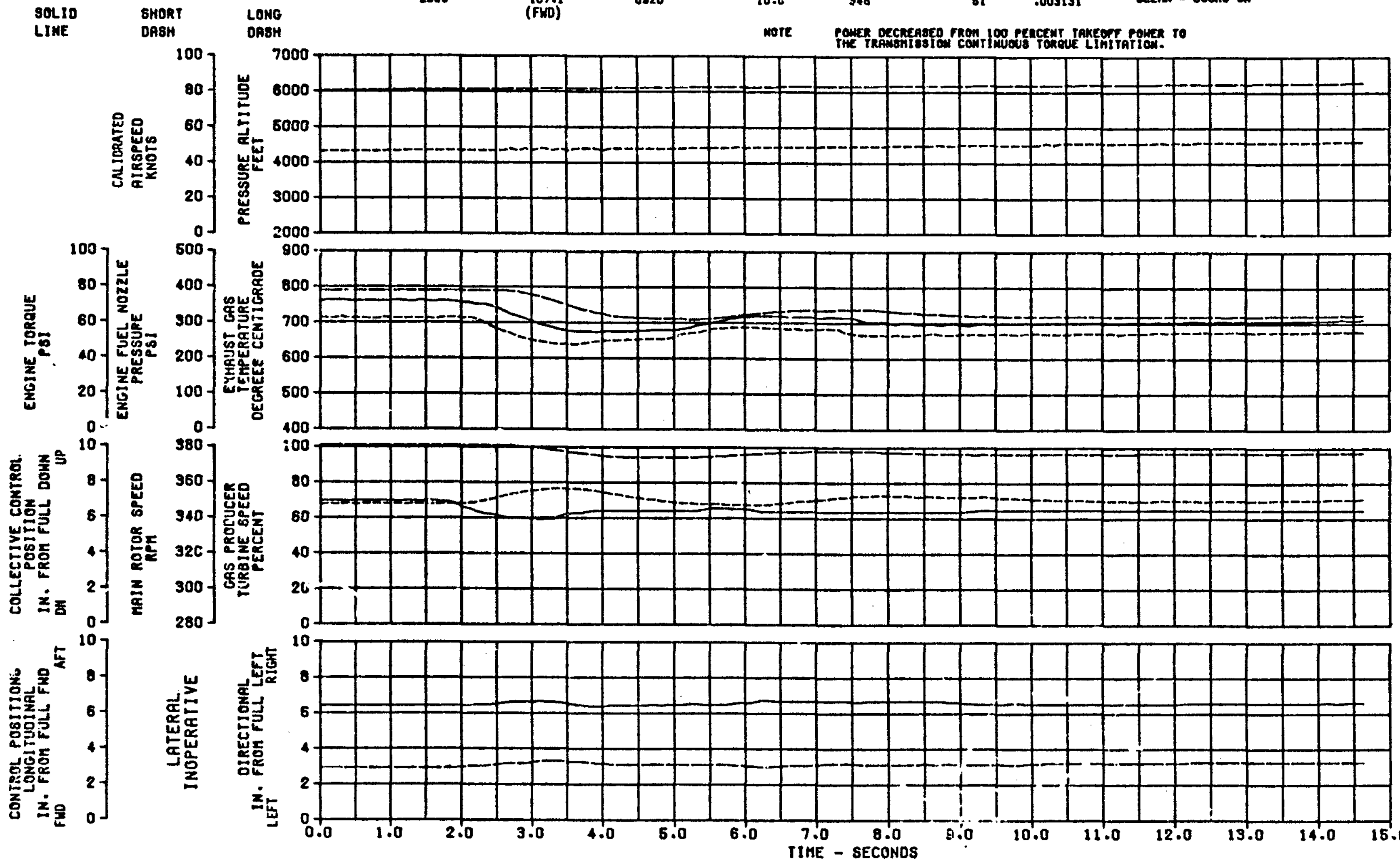


FIGURE 46
ENGINE ACCELERATION AND DECELERATION TESTS
OH-58A USA S/N 16706
MODEL 250 C-20B ENGINE

GROSS WEIGHT ~LB	CG LOCATION ~IN	DENSITY ALTITUDE ~FT	OAT ~DEG C	ROTOR SPEED ~RPM	AIRSPEED ~KCAS	CT	CONFIGURATION
3055	107.4 (FWD)	5380	12.0	363	66	.002832	CLEAN - DOORS ON

NOTE: POWER INCREASED FROM FLIGHT IDLE TO 85 PERCENT OF ENGINE TAKEOFF POWER.

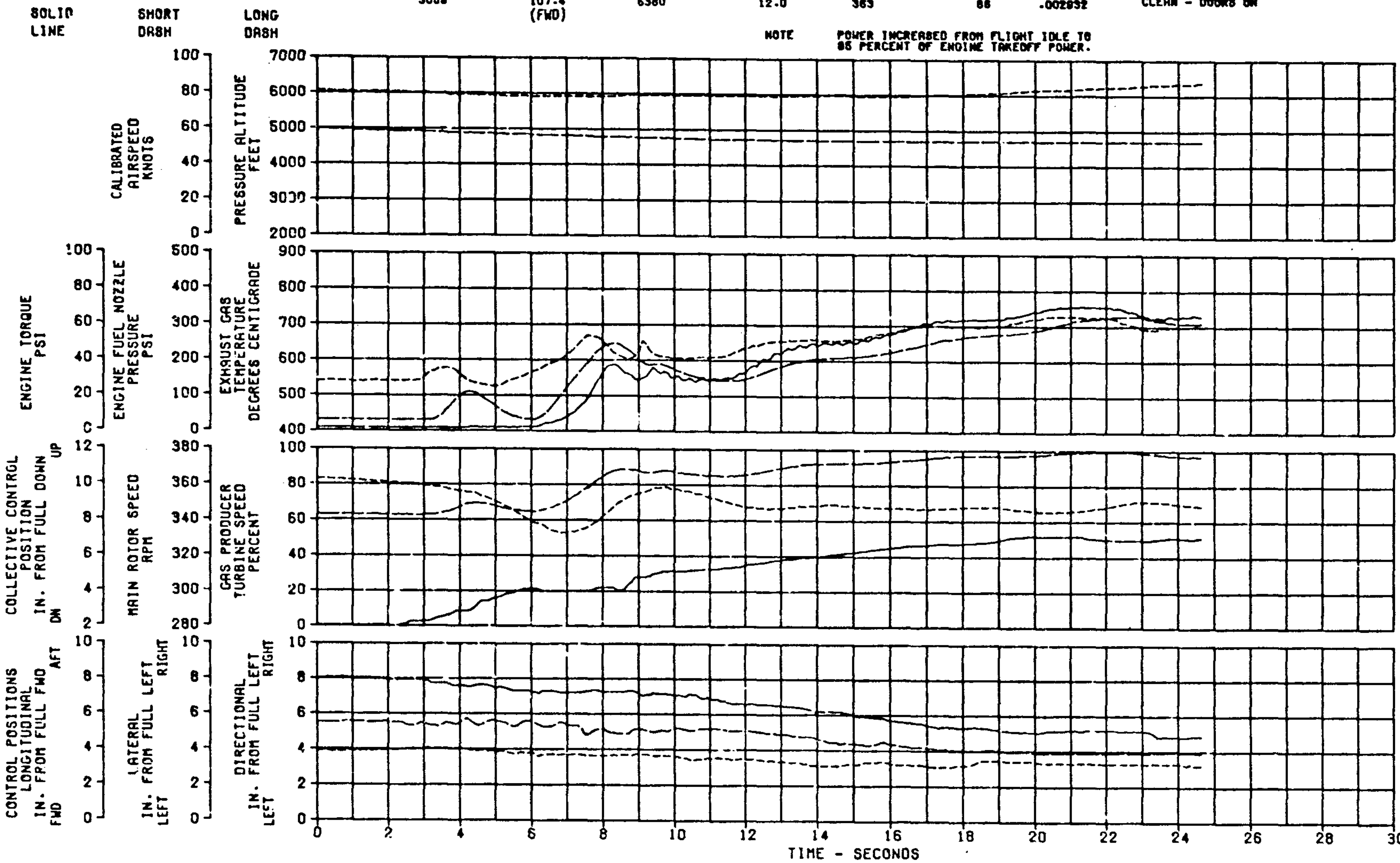


FIGURE 47

ENGINE ACCELERATION AND DECELERATION TESTS

OH-58A USA S/N 18706
MODEL 250 C-20B ENGINE

GROSS WEIGHT ~LB	CG LOCATION ~IN	DENSITY ALTITUDE ~FT	OAT ~DEG C	ROTOR SPEED ~RPM	AIRSPEED ~KCAS	CT	CONFIGURATION
3060	107.4 (FWD)	6120	12.0	372	91	.002783	CLEAN - DOORS ON

NOTE: POWER INCREASED FROM FLIGHT IDLE TO 100 PERCENT OF ENGINE TAKEOFF POWER.

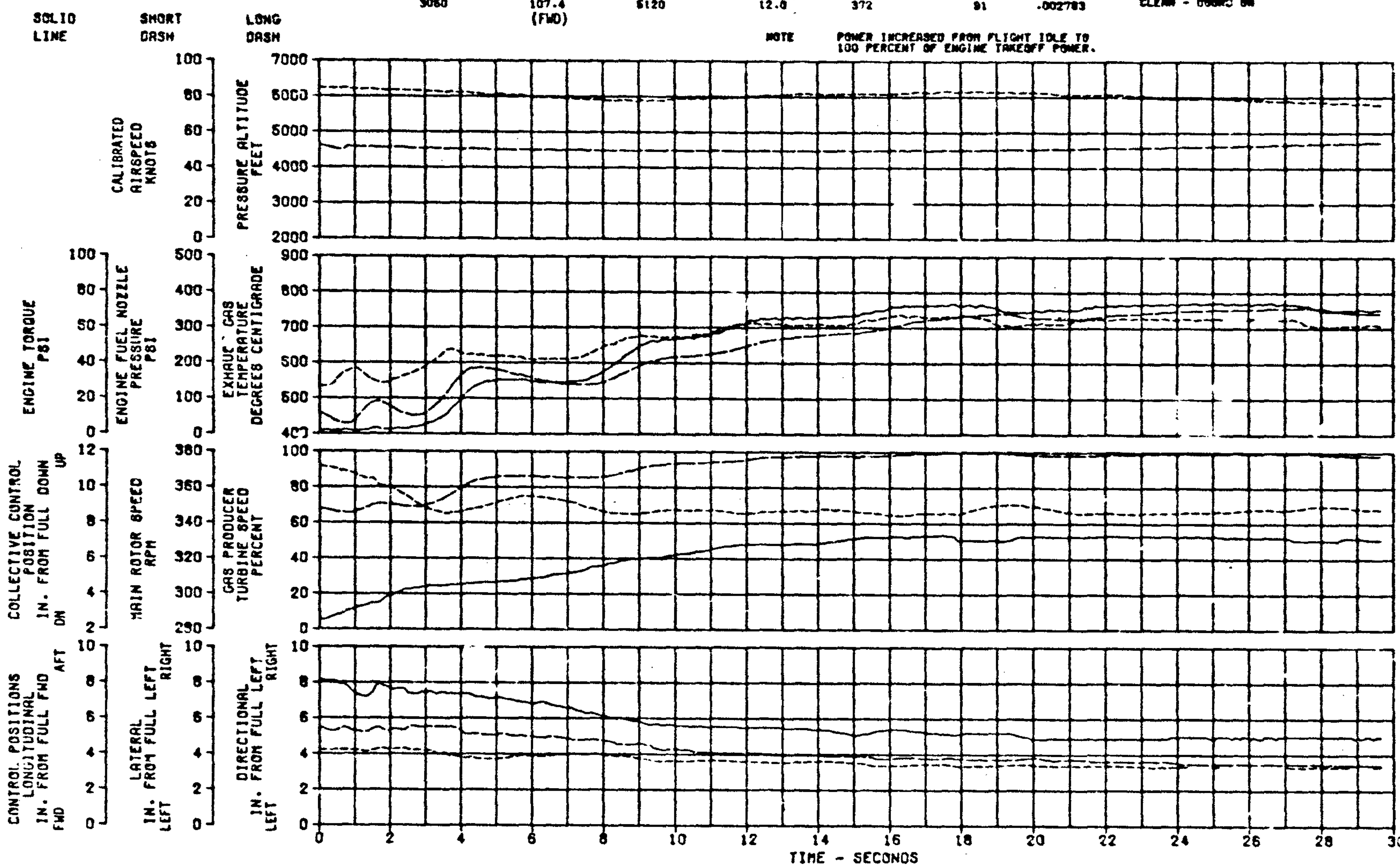
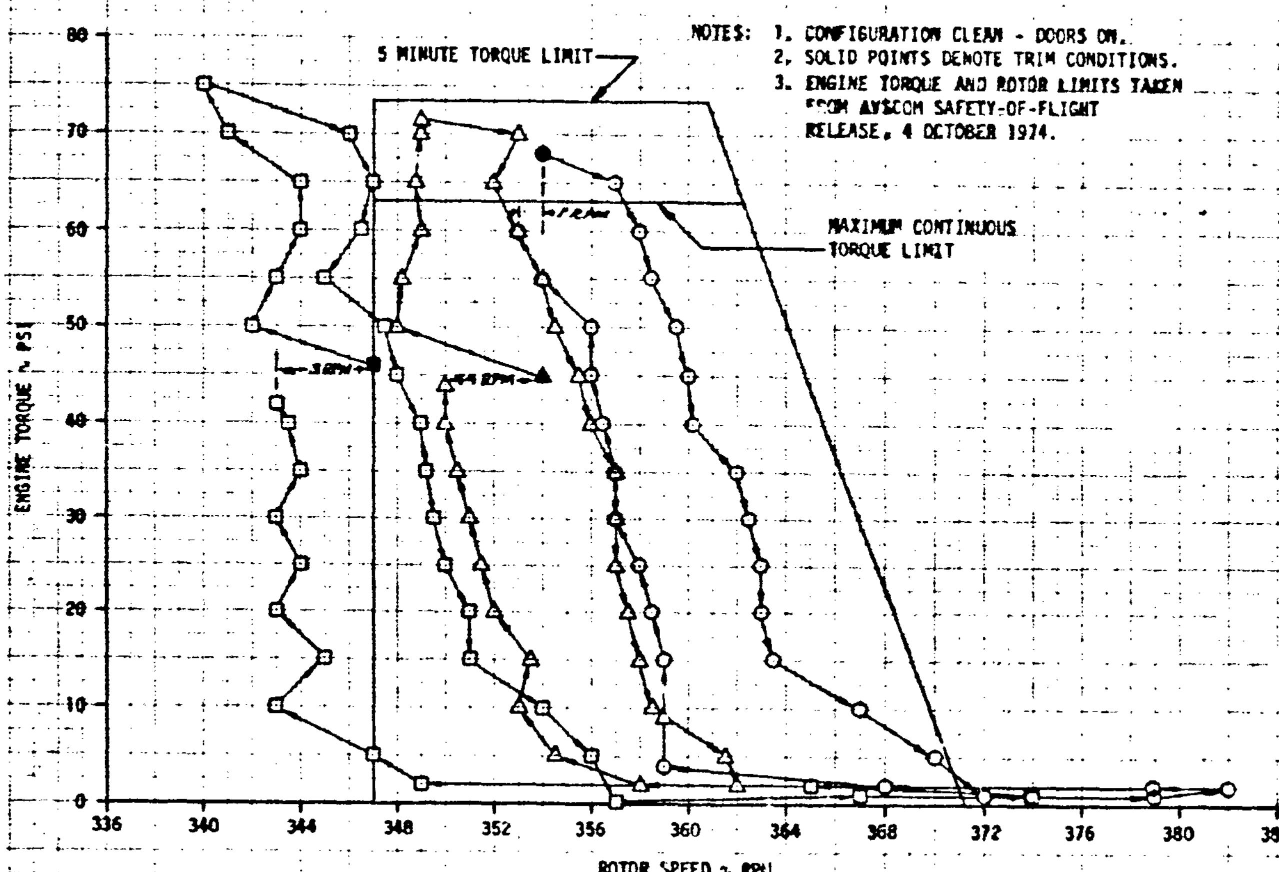


FIGURE 46
STATIC DROOP CHARACTERISTICS
OH-58A USA S/N 68-16706
MODEL 250-C20B ENGINE

SYMBOL	AVG GROSS WEIGHT ~LB	AVG CG LOCATION ~IN.	AVG DENSITY ALTITUDE ~FT	AVG OAT ~°C	TRIM ROTOR SPEED ~RPM	AVG C_T
○	2950	107.0(FWD)	6340	11.0	354	0.003470
△	2930	106.9(FWD)	5160	12.5	354	0.003454
□	2930	106.9(FWD)	4400	14.0	347	0.003479

NOTES: 1. CONFIGURATION CLEAN - DOORS ON.
2. SOLID POINTS DENOTE TRIM CONDITIONS.
3. ENGINE TORQUE AND ROTOR LIMITS TAKEN FROM AVSCOM SAFETY-OF-FLIGHT RELEASE, 4 OCTOBER 1974.



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